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FEBRUARY 1959

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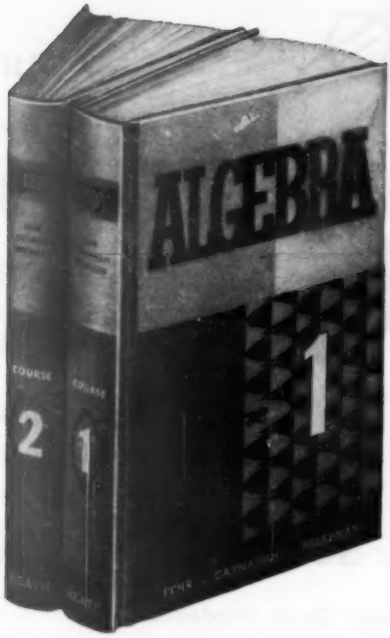

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CONTENTS FOR FEBRUARY, 1959

Astronomical Phenomena for 1959 and Some Classroom Applications—*M. Ira Dubins* 83

y'—Robert Fertig 89

How Effective is Science in the Elementary School?—*Samuel W. Bloom* .. 94

An Aid to Using the Metric System—*Adrien L. Hess* 98

Pythagorean Numbers—*Earl G. Boyd* 99

Successful Practices and Provisions for Enriching the Educational Program for Gifted Students in Junior High School Mathematics and Science—*Monte S. Norton* 101

Why Do Scientists and Engineers Join the Staff of the Argonne National Laboratory?—*W. Charles Redman* 107

Measuring Progress in the "Doing" Skills—*Madelon Colthurst* 114

A One Year Integrated Natural Science Course for Colleges, and Its Problems—*F. C. MacKnight* 121

A Simple Home Made Ammeter—*Dale Kelly* 132

Stimulating Interest in Science—*Leon A. McDermott* 133

A Parabola Scheme—*William R. Ransom* 135

Science and the Curriculum—*Edward K. Weaver* 138

Paper Chromatography for the Secondary Schools, II—*John G. Surak* and *Sr. Mary Lucilda Sewald* 151

Happy Valentine Day to You—*Norma Sleight* 155

The Spool Problem—*Harald C. Jensen* 156

Problem Department—*Margaret F. Willerding* 158

Books and Teaching Aids Received 163

Book Reviews 164

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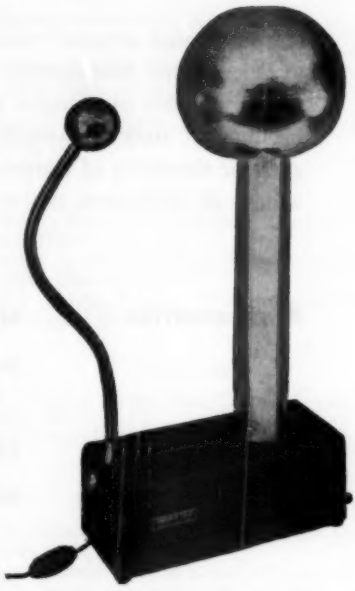

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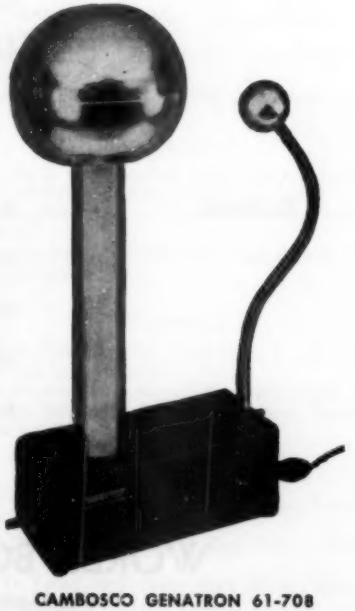

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Astronomical Phenomena for 1959 and Some Classroom Applications

M. Ira Dubins

State University Teachers College, Oneonta, New York

Each year the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. publishes *The American Ephemeris and Nautical Alamanac* for the next year. This annual publication sells for $4.25 and has a wealth of astronomical information. Included in the astronomical phenomena are configurations of the planets with the dates, symbols of the planets, and their configurations. The positions of the planets are given for the entire year. A translation of the symbols was made and the most important planetary configurations selected for this article.

In Figure 1 the planetary configurations of the inferior planets are shown. In order to have a simple diagram it was assumed that E represents the position of the earth for each of the planetary configurations shown. Actually as the inferior planet moves around the sun the earth does also, but if this were done on this diagram, there would be four different positions for E.

When the earth, the inferior planet, and the sun are in line and the inferior planet is between the earth and the sun the planetary configuration is called *INFERIOR CONJUNCTION*. This is represented by point A on Mercury's orbit. As the inferior planet moves westward a point (B) is reached where the angle made by lines from the planet to the earth and the earth to the sun is at a maximum. This is called the *MAXIMUM WESTWARD ELONGATION*. As the inferior planet continues in its orbit at point C it is in line with the sun and the earth. This is called *SUPERIOR CONJUNCTION*.

At point *D* the greatest elongation east is reached, or the *MAXIMUM EASTWARD ELONGATION*. When the planet reaches a point where it is between the sun and the earth and all three are in a straight line, *INFERIOR CONJUNCTION* has been reached and a new cycle of planetary configurations started.

In Figure 2 the planetary configurations of the superior planets are shown. The same assumption as made in Figure 1 has been made with Figure 2. The superior planets have orbits at greater distances from the sun than the earth.

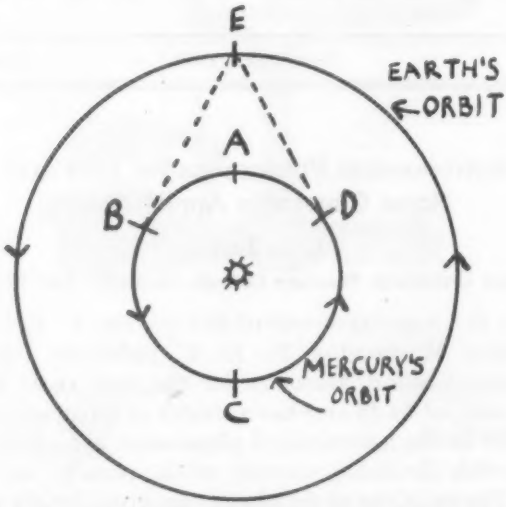

FIG. 1. Planetary configurations of the inferior planets.

When the superior planet, the earth, and the sun are in a straight line so that the earth is between the planet and the sun, the planetary configuration is called *OPPOSITION*. This is represented by point *F*. At point *G* the planet is at *WESTERN QUADRATURE*. Here a line drawn from the planet to the earth and one drawn from the earth to the sun make an angle of 90 degrees. This does not occur with the inferior planets. As the planet continues on its orbit point *H* is reached where the planet, the sun, and the earth are on a straight line. However, this time the sun is between the planet and the earth. This position is termed *CONJUNCTION*. At *I EASTERN QUADRATURE* is reached and at *F* once again the planet is in *OPPOSITION* and a new cycle of planetary configurations has started.

This information can be used in several ways by the general science teacher at the junior or senior high school level. A study of the phenomena for each planet as given in the later part of this article will reveal a pattern that is followed by the planet. Ask the student if he

can discover the pattern. This will provide him with an opportunity for thinking and interpretation of data. The patterns for inferior planets differ from superior planets, and the cycle can start with any configuration as long as it ends with the same planetary configuration (which is the start of the next cycle).

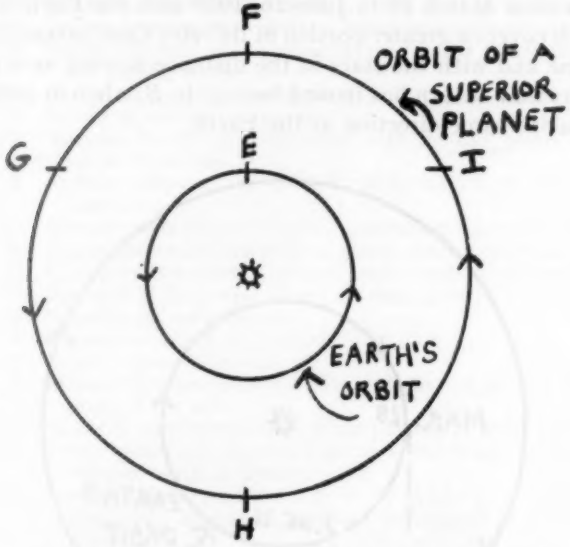

FIG. 2. Planetary configurations of the superior planets.

When is a planet closest to the earth? This occurs when a superior planet is at *OPPOSITION*. What is the significance? We can see more when the planet is closer and the best time for shooting a rocket to a planet is when it is closest to the earth. The Astronomical Phenomena list the opposition dates of the planets. From the planetary configurations one can tell when the planet will be visible.

How many teachers have been asked, "How do the planets line up?" This question can be answered by drawing a circle representing the orbit of the earth and dividing it into 365 parts so that the position of the earth in its orbit can be represented for each 10 or even 20 days during one year. Then concentric circles are drawn representing the orbits of the other planets. The dates of opposition, inferior conjunction, and superior conjunction, eastern and western quadratures, and the elongations are plotted on the orbits of the planets arranging the plotting so that these points can be determined with reference to the position of the earth (the sun being at the center of all of the orbits) at those times. Now one can see the relative positions of the planets at different times during the year, and in addition one can see how slowly some of the planets move.

By plotting on concentric circles the positions of a superior planet and the earth at different times of year, retrograde motion can be readily seen. The planets appear to move from west to east and then at times reverse their motion moving from east to west. This phenomenon is illustrated in Figure 3. The actual movement of Saturn is shown from March 28 to June 26, 1959 as is the Earth's. Because the Earth covers a greater portion of its orbit than Saturn during the same time and with the stars in the distance serving as a reference, it appears that Saturn has moved from A to B, when in reality it has moved in the same direction as the Earth.

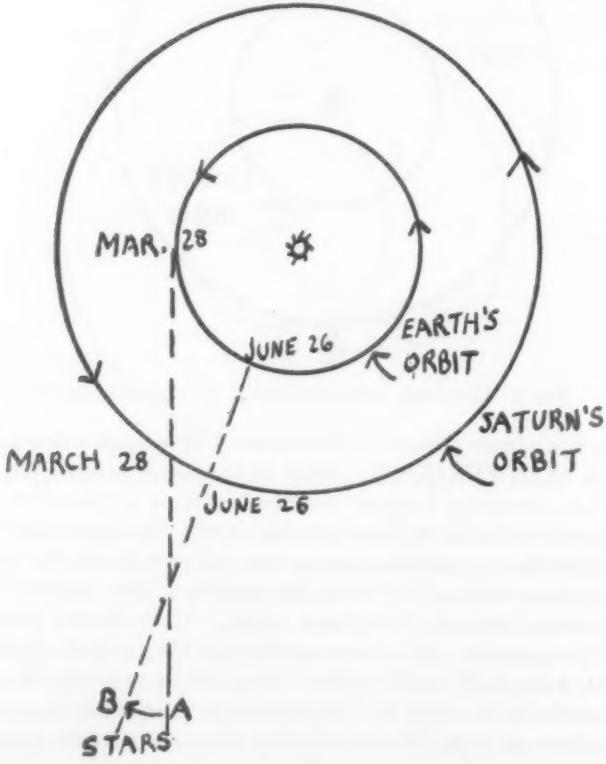

FIG. 3. Apparent retrograde planetary motion.

ASTRONOMICAL PHENOMENA—1959

January	2	Earth closest to sun, perihelion
	11	Mercury in conjunction with Saturn, passes 45 minutes south of Saturn
	27	Neptune in eastern quadrature

February	3	Uranus opposite sun
	8	Neptune ends eastward motion; begins westward drift
	14	Mercury in superior conjunction with the sun
	20	Jupiter in eastern quadrature
	22	Pluto opposite the sun
	26	Mars in eastern quadrature
March	12	Mercury farthest east of the sun
	19	Mercury ends eastward motion; starts moving westward
	19	Jupiter ends eastward motion; begins moving westward
	21	Vernal Equinox; sun overhead at the equator today, with apparent motion northward
	24	Partial eclipse of the moon not visible in the U. S., but in Europe
	28	Saturn in eastern quadrature
	29	Mercury in inferior conjunction with the sun, passes 3 degrees north of the sun
April	8	Annular eclipse of the sun not visible in the U. S., but visible in Australia
	10	Mercury ends westward motion, starts moving eastward
	16	Saturn ends eastward motion, starts moving westward
	20	Uranus ends westward motion, begins moving eastward
	26	Mercury farthest west of sun, 27 degrees and 11 minutes
	26	Neptune opposite the sun
May	3	Uranus in eastern quadrature
	18	Jupiter opposite the sun
June	3	Mercury in superior conjunction with the sun, passing 40 minutes north of the sun
	14	Venus in conjunction with Mars passing 51 minutes north
	20	Venus in conjunction with Uranus; Venus passes 1 degree and 17 minutes north of Uranus
	22	Summer solstice; sun overhead today at 23.5 deg. North latitude, maximum distance in northern hemisphere at which it is at zenith
	23	Venus greatest elongation east, 45 degrees and 25 minutes
	24	Mars in conjunction with Uranus passing 39 minutes north
	26	Saturn opposite the sun
July	5	Earth farthest distance from sun, aphelion
	8	Mercury farthest east of sun
	12	Mercury in conjunction with Uranus; passes 1 degree and 48 minutes south of Uranus
	17	Neptune reaches maximum westward position, starts eastward
	20	Jupiter ends westward motion, starts eastward
	22	Mercury starts moving westward
	26	Venus at greatest brilliancy
	28	Neptune in western quadrature
August	5	Mercury at inferior conjunction with the sun; passes 4 degrees and 52 minutes south of the sun
	8	Venus ends eastward motion, starts moving westward
	10	Uranus in conjunction with the sun
	11	Venus in conjunction with Mars; Venus passes 6 degrees and 46 minutes south of Mars
	16	Jupiter in western quadrature
	23	Mercury greatest westward elongation, 18 degrees and 25 minutes
	28	Pluto in conjunction with the sun
September	1	Venus in inferior conjunction with the sun; Venus passes 8 degrees and 34 minutes south of the sun
	5	Mercury in conjunction with Venus; Mercury passes almost 11 degrees north of Venus

	5	Saturn ends westward motion, starts eastward
	17	Mercury in superior conjunction with the sun; Mercury passes 1 degree and 33 minutes north of the sun
	21	Venus ends westward motion, starts eastward
	23	Autumnal Equinox; sun at Zenith at the equator; apparent motion into the southern hemisphere
	24	Saturn in western quadrature
	30	Mercury in conjunction with Mars; Mercury passes 10 minutes south of Mars
October	2	Total eclipse of the sun visible as a partial eclipse along the Atlantic coast from Maine through Florida and west as far as Michigan; total eclipse visible over part of the North Atlantic Ocean and parts of North Africa
	8	Venus at its greatest brilliancy
	13	Mercury in conjunction with Neptune passing 3 degrees 5 minutes south of Neptune
	30	Mars in conjunction with the sun
	30	Neptune in conjunction with the sun
November	1	Mars in conjunction with Neptune passing 1 degree and 33 minutes south of Neptune
	3	Mercury at greatest eastward elongation, 23 degrees and 33 minutes
	7	Mercury in conjunction with Jupiter; Mercury passes 3 degrees and 23 minutes south of Jupiter
	12	Venus farthest west of the sun
	14	Mercury starts its westward motion
	17	Mercury in conjunction with Jupiter; Mercury passes 2 degrees south of Jupiter
	24	Mercury in conjunction with sun; Mercury passes 45 minutes north of the sun
	27	Uranus reaches eastward maximum and starts west
	28	Mercury in conjunction with Mars passing 2 degrees and 5 minutes south of Mars
December	3	Mercury ends westward motion, starts eastward
	12	Mercury at greatest west elongation, 21 degrees 3 minutes
	14	Venus in conjunction with Neptune, passing 46 minutes north
	22	Winter solstice; sun overhead at 23.5 degrees south latitude
	25	Mercury in conjunction with Mars, passing 57 minutes south
	27	Mercury in conjunction with Jupiter, passing 2 min. south
	29	Mars in conjunction with Jupiter, passing 49 min. south
	31	Saturn in conjunction with the sun

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However, the figures are only preliminary calculations based on laboratory experiments.

Hydrogasification, as the process is called, was described as a one-step process during which crushed oil shale is treated with hydrogen at high temperature and pressure.

y′

Robert Fertig

Burlingame High School, Burlingame, California

The RATE CONCEPT is of extreme importance to those who will apply mathematics in the fields of engineering, science, and business. It should be presented to them as early as possible, in varying ways, until it is a natural part of their means of communication.

Geometry and the Rate-Concept

A) SLOPE of a line.
B) SLOPE of a secant (between two points of a curve).
C) SLOPE of a tangent (at a point of a curve).
D) Definitions and symbols:

DIFFERENCE or CHANGE is represented by the greek letter DELTA: Δ
DISTANCE is represented by s (to avoid confusion with diameter: d)
VERTICAL distance : y
CHANGE in y: Δ_y
HORIZONTAL distance: x
CHANGE in x: Δ_x
TIME is represented by t.

Illus 1: (Running start). If a hot-rod at time $t=3$ seconds is at the 90 ft. marker, and at time $t=5$ seconds is at the 210 ft. marker, then the difference (or change) in distance is: $\Delta_s=210-90=120$(ft.). The difference in time is: $\Delta_t=5-3=2$(sec.).

E) RATE or RATIO is a fraction or a quotient of two items.

Illus 2: In #1, the average rate (or speed) $\bar{r}$ of the hot-rod is the change in distance divided by the change in time: $\bar{r}=\Delta_s/\Delta_t=120$ ft./2 sec. $=60$ ft./sec. (60 feet per second). This is an average rate, hence the $\bar{r}$ (Note: the data does not tell us whether the car was accelerating or decelerating; discuss).

F) "|VELOCITY| = speed."

This means that velocity without its directional indications is the same as speed. If an object is moving to the left we might say its velocity is -60 ft./sec.

G) CONVERSION FACTORS:

To convert approximately from ft./sec. to mi./hr., multiply by 2/3; and conversely by 1.5

Illus 3: 60 ft./sec. times $2/3=40$ mi./hr.; 2000 mi./hr. times $1.5=3000$ ft./sec.

H) INDEPENDENT VARIABLE. $y(x)=4x^2-12x+10$.

This is a formula showing the manner in which y depends upon x

(x is the independent variable). $y(3)=4(3)^2-12(3)+10=10$ means: when $x=3$, $y=10$. $y(x+a)=4(x+a)^2-12(x+a)+10$. Simplify. Verify that

$$\frac{y(x+a)-y(x)}{a}=8x-12+4a.$$

I) SLOPE, GRADE GRADIENT.

These measure the rate of rise (or fall) of a hiway, temperature, pressure, income, etc. In a hiway a 6% grade means that the change in elevation is 6 ft. for every 100 ft. of map distance; grade $=\Delta_y/\Delta_x=6$ ft./100 ft. $=.06$. If the hiway is level, the grade $=0$ ft./100 ft. $=0$. Draw a picture of such a hiway. In mathematics we say that its slope is zero.

Illus 4: If the temperature at time 2 microsec. (millionths of a second) was 20°C. and at 4 microsec. was 100°C., what was the average temperature-gradient during this time interval?

$$\bar{g}=\Delta_T/\Delta_t=80°\text{C.}/2\cdot 10^{-6}\text{sec.}=40{,}000{,}000°\text{C./sec.}$$

What man-made device might yield such a high temperature-gradient?

J) Slope of lines, such as $y(x)=3x-2$. (See fig. 1).

$$y(1)=3(1)-2=1; \qquad y(0)=-2;$$

slope

$$m=BC/AC=\Delta_y/\Delta_x=y(1)-y(0)$$

divided by $1-0=1-(-2)=3$. The slope m is 3 or 3:1 or 3/1 as preferred. Verify the geometry.

If we always observe how y changes as x INCREASES, we can quickly determine the sign of the quotient.

Memory scheme:

As x increases and y increases, the slope is positive (>0);

As x increases and y decreases, the slope is negative (<0).

The slope is always the coefficient of x when $y=mx+b$.

If $y=3x-2$, the slope is 3. Verify that if $3x+2y=6$, the slope $m=-3/2$.

K) Slope of a secant.

Illus 5: Given: $y(x)=.2x^2$. Required: slope m of secant through A and B, (See fig. 2) A: (3,) and B: (4,).

Solution:

$y(3)=1.8$, so A: (3, 1.8); $y(4)=3.2$, so B: (4, 3.2). $m=\Delta_y/\Delta_x$ $=(BD-AC)/CD=y(4)-y(3)$ divided by $(4-3)=1.4$. Explain the algebra and geometry.

Illus 6: In #5, calculate the slope of the secant through A and C where C: (3.0+.1,). Verify: $m=1.22$.

Illus 7: In #5 calculate the slope of the secant through A and D where D: (3.00+.01,). Verify: $m=1.202$.

Illus 8: In #5 calculate the slope of the secant through A and W where W: $(3+10^{-12},)$. Verify: $m=1.200\ 000\ 000\ 000\ 2\cdots$

L) Slope of a tangent.

In #5–8 the secants AB, AC, AD, $\cdots$, AW were discussed. As points B, C, D, $\cdots$, $W\to A$ (approached A) the positions of the secants→the position of the tangent at A. (Recall that the LIMITING position of the secants of a circle through A is the tangent to the circle at A). In #9, as $W\to A, \Delta_x\to 0, \Delta_y/\Delta_x\to d_y/d_x$ (d might mean diminutive, very much so!). (Note: a quotient d_y/d_x can be measureable, although d_y and d_x might not be, i.e.: $y'=d_y/d_x=1.2\cdot 10^{-1000}/1\cdot 10^{-1000}=1.2$

Illus 9: In #5, calculate the slope of the secant through P: $(x_1,)$ Q: $(x_1+\Delta,)$. Sol: $m=y(x_1+\Delta)-y(x_1)$ all divided by $(x_1+\Delta)-x_1$. Verify that $m=.4x_1+.2\Delta$. (Δ used for Δ_x).

Illus 10: In #9 if $Q\to P$, the secant→tangent, $\Delta_x\to 0, \Delta_y/\Delta_x\to d_y/d_x=y'$. Therefore $y'=.4x_1$. Specifically, the slope of the tangent at A is $y'(3)=.4(3)=1.2$. Compare this answer with that of #8.

Illus 11: Given: $T(s)=-5s^2+30$ (T is the temperature in °C., and s is the distance in meters). The equation describes the temperature at various distances from one end 0 of a tapered piece of metal when heated at that end. Calculate the rate of change of temperature with respect to a change in the distance from 0 for the point A where $AO=n$ meters. Verify: $\bar{r}=\Delta_T/\Delta_s=-10n-5\Delta_s$; $T'(n)=-10n$.

Rockets

What are some of the things we might want to know about an object, perhaps a possible earth's satellite? Consider something propelled upward vertically. What would be its elevation above zero at any specified instant? What is the maximum elevation it might achieve? What would be its velocity at any instant? Is there a minimum velocity, if so, what is it and when will it occur? When will it come down?

Physical experiments in laboratories enable us to accumulate data which can be tabulated. One might take observations of the elevation of the object at uniformly increasing values of time.

Subsequent mathematical procedures might be: graph the tabular data (the independent variable time horizontally); assume the relationship between the elevation and time to be some function $s(t)$. (See section on Curve-fitting.) This equation might be:

$$s(t)=-16t^2+186t+30.$$

By merely investigating the graph the scientist might find adequate approximate answers to his questions, but then his native inquisitiveness begins to assert itself.

"If I propelled the object at a different initial velocity, or from a different elevation, could I possibly predict the results before actually performing the experiment?"

He might observe that the coefficient of t $(+186)$ was apparently the same as the initial velocity, and that the constant term $(+30)$ was apparently the same as the initial elevation of the rocket. His tentative conclusions might be: "The $+30$ is the elevation at time zero: $s(0)=30$ (ft.). The $s(t)=\cdots+186t\cdots$ is our old 'distance equals rate times time concept,' the $+$ sign indicating the direction of the velocity. Therefore the elevation of the object 3 seconds after take-off might have been $s(3)=\cdots+186(3)+30=588$ (ft.) were it not for opposing forces. The $s(t)=-16t^2\cdots$ portion might conceivably represent the motion of the object if it were merely released at time zero, elevation zero, and allowed to fall freely."

The scientist might proceed to concentrate upon this latter part of the formula in an attempt to verify and understand its implications. If he has the true curiosity and imagination of the scientist, he may even investigate how this term might vary if the experiment were performed at varying distances from the earth's center, points on the equator being more remote than those nearer the poles. He might also investigate the effect of air resistance, or even the weight and the shape of the rocket itself.

His next question might be, "Can I predict the maximum elevation of an object not yet propelled whose initial velocity is 2000 ft./sec., if its starting point is 5280 ft. above sea-level? Obviously I could prepare a table of values or even graph the relationships. Is there a faster algebraic method, or formula? If so, I can foresee applications in other fields for such a method: (a) when will the voltage in a certain circuit be a maximum, and what will this voltage be? (b) what is the minimum surface material for a maximum capacity of a cylindrical container?"

The scientist might further theorize: "The analogy between the abstract geometry of the graph and the concrete problem of the object propelled vertically is:

Geometry: The slope of the tangent at any time t is:

$$s'(t)=-32t+186.$$

Rocket: The velocity of the rocket at any time t is:

$$v(t)=-32t+186.$$

Geometry: When the slope of the tangent is zero, the height of the curve is a relative maximum.

Rocket: When the velocity of the rocket is zero, the elevation of the rocket is a maximum.

"I can find the maximum value of a quantity $Q(t)$ with respect to (say) time if I first determine the formula for the average rate of change of Q during any small time interval Δ_t: $\bar{r}=\Delta_Q/\Delta_t$ $=Q(t+\Delta_t)-Q(t)$ all divided by $(t+\Delta_t)-t$. If I let the time interval $\Delta_t \to 0$ I can obtain the formula for the instantaneous rate of change of Q at any time t: $Q'(t)=\cdots$. To obtain the time at which the maximum (or minimum) value of Q occurs, I can set $Q'(t)=0$ and solve for t. If this is $t=a$, then $Q(a)$ is the maximum value."

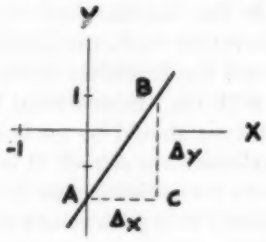

FIG. 1

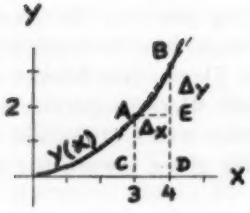

FIG. 2

CHLOROPHYLL COMPOUNDS SHOW HEART-HELPING ACTION

Chlorophyll, the substance that is responsible for sustaining all life, may prove to be life-saving.

Two classes of chlorophyll compounds have been shown to have a beneficial effect on laboratory animals with induced heart failure. The compounds are known as chlorins and rhodins.

Their effect on heart disease has been demonstrated many times on the hearts of frogs, rats, rabbits and dogs.

It must be remembered that the materials are not yet ready for testing on human beings; and eating large quantities of vegetables rich in chlorophyll is not the same as treating laboratory animals with chlorophyll derivatives.

How Effective Is Science in the Elementary School?*

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The effectiveness of any science program depends largely, perhaps entirely, upon the competency and the initiative of the individual teacher and her professional outlook. When the teacher is dynamic, creative, and interested in doing things, there is an outgoing science program. When this spirit is lacking, there is an ineffectual program. Any discussion of the effectiveness of science in the elementary school begins, therefore, with the teacher and necessarily includes the attitude of the administrative staff, the quality and quantity of instructional materials, and the flexibility of the curriculum.

If we are concerned with the "Educational Frontiers in the Age of Outer Space," our emphasis should be on how we can improve our science program in the elementary school. It is not enough to sit back complacently to evaluate its effectiveness. (I am implying no criticism of evaluative devices.) It is paramount that we look forward to the future to see how we can improve our present practices and how we can sharpen our techniques.

One can be optimistic at the present outlook. More and improved science teaching is taking place in the elementary schools. More teachers are seeking to learn how to teach science than at any time in history. Workshops in Elementary Science are crowded; panel discussions are well attended; science supervisors are being appointed in communities where science was a step-child in pre-Sputnick times; and serious study is being given toward the revision and evaluation of science curriculums.

Wherein do our difficulties lie? What have been our weak points in presenting an effective science program in the elementary school? Let us analyze some of the factors mitigating against an effective science program:

1) First, and foremost, the weakest link in our chain is the timid teacher, the teacher who is afraid of science, who feels insecure and imparts this fear and insecurity to her class.

Such a teacher is a common phenomenon. She is found in every school and in every school system. She is not necessarily the older teacher. Frequently, she is the recent graduate who is a product of the pre-professional type of science course presently taught in our colleges and universities. Most science courses are designed to turn out specialists in a given scientific field rather than teachers capable of teaching. Prospective teachers need courses which stimulate them

* A paper prepared for presentation at the Third Annual Teachers' Congress of St. John's University, Brooklyn, New York, November 11, 1958.

and lead them to appreciate the intellectual aspects of science. Such courses, unfortunately, are virtually nonexistent although many alert educators, particularly in the New York area, have taken steps to modify courses in order to meet the needs of teachers more appropriately. These new courses are not watered-down versions of standard courses but are rigorous science courses designed for a particular purpose, viz., to help the prospective teacher.

What is the solution for the timid teacher? How can this teacher be helped? There are many approaches to this problem but they are all contingent upon an abundance of time and energy. If we are to make the science program more effective, the teacher should be prepared to participate in workshops, serve on curriculum committees, attend special college classes, et cetera. These in-service and college courses are extremely valuable and important, especially, to the timid, insecure teacher.

2) A second difficulty with our science program as presently constituted is the administrators' insistence on what we like to refer to as "Pins, Paste, and Paper." Administrators seem to feel that a good science program can be operated with a minimum or no funds. An effective science program requires some basic equipment and a reasonable quantity of supplies. The teaching of science should not depend solely upon the ingenuity of the teacher and the good graces of the community. Teaching science costs money and administrators should be made aware of this fact.

It is true that many science units of instruction can be taught effectively with no expenditure of money. On the other hand, classrooms require cages for animals. They should be provided with aquaria and terraria. Classrooms should have magnets, barometers, thermometers, hydrometers, among other things. Why should teachers be expected to build these or similar items, expending energy and time which could be more beneficially and professionally utilized working with individual children or groups. Many items can be scrounged from the community. This fact, however, does not obviate our thesis that science costs money, that funds for instructional material should be available when needed with a minimum of red tape.

Of course, we should also learn to do the maximum with "Pins, Paste, and Paper." We must learn to take advantage of every community source and resource and try to present concrete materials from which our children get the experiences so vital to an understanding of the concepts of science.

3) A third difficulty with our present science program is the attempt, frequently made, to integrate science with other subject matter. Ideally, science should be taught as part of the functional whole of man's knowledge. It should be integrated with the reading pro-

gram. Science is quantitative, and arithmetic is part of the program. But, in practice, unless science is taught as a separate entity, it becomes of secondary importance. Too often, worthwhile scientific learning experiences are jeopardized and the learning of science deteriorates into another course in reading. When the public clamors "why Jimmy can't read," Jimmy is sometimes given more reading and less science. Furthermore, the teaching of science requires more effort, greater preparation, and more teacher-pupil planning. We are all human. It is easy to take the course of least resistance. We neglect science for those elements in our curriculum with which we are more familiar.

For these reasons, we recommend that science should be taught as an entity—not removed from reading, writing, or arithmetic, but expanded from these tool subjects to enlarge the scientific and intellectual horizons of our pupils. Pupils should have not just one text book but many. Books, magazines, and pictures should be accessible. At the same time, the pupils should be working with THINGS, using their hands, making and recording observations, learning facts from which they can generalize. Reading materials, textbooks and reference books are helpful but should be supplementary to real science experiences on the part of pupils.

Facts should not be avoided. It is from the sum total of our learned experiences that we form our concepts and learn to understand principles. We should be aware that the "fact" of today may not be the "fact" of tomorrow. Facts are subject to interpretation—and in science we use facts to reach new interpretations.

How much time should be devoted to science? This is a debatable point. How much time is required to develop functional information, skills, attitudes, and appreciations? It is obvious that the curriculum should be flexible enough to provide for the special interests of both groups and individuals. The curriculum should be flexible enough to provide more time at one level than at another. The length of time devoted to science should be such that successful accomplishment of the daily objectives can be reached. Just how long this span of time should be cannot be categorically stated. It would seem that 15 to 20 minutes a day in the primary grades with increased time in the upper grades is very appropriate and in accord with the objectives of science education and the science interests of the child.

4) A fourth difficulty with our science program has been the curriculum. In many schools, science has been incidentally introduced through the interests and questions of children. This is a "back-door" approach. In other schools and in science-oriented communities, the influence of the times has produced a highly definitive curriculum with a rigid, planned approach. Neither approach takes fully

into account what psychology has shown us about how children learn.

The interest and questions of children should not be ignored. They often lead to many excellent learning opportunities. However, unless a program can be developed from incidental learning, the chief outcomes anticipated from a science program are seldom attained from a casual approach.

A suggested science curriculum for the elementary school should include a planned program within a framework sufficiently flexible to permit outlets for the interests of both pupils and teachers. It should be a program flexible enough to permit ample opportunity for pupil-teacher planning. It should be the type of program which permits current happenings in science to become an integral part of the science curriculum. Moreover, this flexible curriculum should allow for a spiral approach to understandings as the child matures and passes from grade to grade. The objectives of our science program should be considered as guides for growth rather than as final outcomes. And ample opportunity should be provided for the development of functional information, skills, attitudes, and appreciations.

We should not overlook the great number of beautifully illustrated, scientifically correct science books which are currently being written for the child of elementary school age. The teachers' manuals which accompany these books offer many enrichment opportunities. Science experiences are frequently suggested which provide the opportunity for the child to explore, to manipulate, and to experiment with the phenomena of their local environment. These books encourage teachers to plan in terms of the instructional group with which she is working and thus to supplement the curriculum.

General Conclusion

Science is in a key position to make significant contributions to the larger goals of general education. As a body of classified knowledge, science contributes to the understanding of facts, concepts and principles that function in the adjustment of pupils to life's problems.

The scientific method of investigation contributes skill in identifying, attacking and solving problems. Attitudes, such as open-mindedness and intellectual honesty are developed by experiences using the methods of science. As a social force, science influences the lives and welfare of people.

Specifically, at the elementary level the science program has the following unique opportunities and responsibilities:

1) to deepen understanding and appreciation of the environmental factors and their control

2) to increase the knowledge of, and the ability to apply scientific principles
3) to improve continually the ability to use the methods of science in attacking every day problems
4) to increase the understanding of the impact of science upon the individual and society.

It should be the function of each teacher to implement and develop these outcomes. A creative teacher supported by an alert administrative staff, strengthened with ample instructional materials, and guided by a flexible curriculum adapted to the the neeeds and interests of the children will continually increase the effectiveness of the science program in the elementary school.

An Aid to Using the Metric System

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Beginning students often have considerable trouble converting from one unit to another unit in the metric system. The device given below is one the author has found quite helpful to students who must use the metric system.

To illustrate how to use the device, consider changing centimeters to kilometers. This is going down in the chart and hence one divides. The divisor is 100,000 $= 10^5$. The exponent 5 is the number of tens passed over in moving from centi to kilo. The decimal point is moved to the left as shown by the arrow at the bottom. The device is set up on a clockwise movement. Furthermore, the first letters of the words "divide," "left," "multiply," "right" are in alphabetical order, i.e., *d*, *l*, *m*, *r*.

Pythagorean Numbers

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NOTE: The numbers in parentheses will refer to certain number forms or equations.

INTRODUCTION

The purpose of these notes is to determine a criteria whereby sets of rational integral numbers may be found to satisfy the equation $x^2+y^2=z^2$.

DEFINITIONS

Any set of rational numbers that satisfy the equation $x^2+y^2=z^2$ is called a set of pythagorean numbers. Any rational multiple of a set of pythagorean numbers is a set of pythagorean numbers.

A set of pythagorean numbers which does not have a common multiple is called a primitive solution.

SQUARES OF NUMBERS

All even numbers are in the form of $2n_0$, and all odd numbers are in the form of $2n_0+1$. The squares of all even numbers are even and in the form

$$4n \ (1). \quad (2n_0)^2=4n_0^2=4n.$$

The squares of all odd numbers are odd and in the form

$$4n+1 \ (2). \quad (2n_0+1)^2=4n_0^2+4n_0+1=4(n_0^2+n_0)+1=4n+1.$$

The sum of two odd squares is not a square.

$$(2) \quad (4n_0+1)+(4n_1+1)=4(n_0+n_1)+2=4n+2 \ (3).$$

This is not the square of an even since it would have to have the factor 4(1). This is not the square of an odd (2) since it is even (3).

PRIMITIVE SOLUTIONS

$x^2+y^2=z^2$. If x and y are both even, we would not have a primitive solution, since they would both have the factor 4(1). If x and y are both odd—as we have already shown the sum of two odd squares is not a square (3); one must, therefore, be odd (x and y) and one even for a primitive solution. Let x be the even and y the odd. Then, x^2 is an even (1) and y^2 is an odd (2). x^2+y^2 is an odd, since the sum of an even number and an odd number is an odd number.

$$2n_0+(2n_1+1)=2(n_0+n_1)+1=2n+1 \ (2).$$

Therefore z and z^2 are both odd for only the squares of odd numbers are odd, see (1) and (2).

$x^2=z^2-y^2$. $x^2=(z-y)(z+y)$. $(z-y)$ and $(z+y)$

are both even since z and y are both odd. Let:

$$\begin{cases} z+y=2k \\ z-y=2h \end{cases} \qquad \begin{cases} z=k+h \quad (5) \\ y=k-h \end{cases} \qquad \begin{matrix} z^2-y^2=4kh \\ x^2=4kh \quad (4) \end{matrix}$$

We must now take h and k relatively prime, for if they had a common factor "f," it would be a factor of z and y, and we would not have a primitive solution. Since (4) $4hk$ is a square and k and h are relatively prime, it follows that k and h are squares. Let $k=m^2$ and $h=q^2$. Substituting in (5):

$$\begin{cases} z=m^2+q^2 \quad (6) \\ y=m^2-q^2 \end{cases} \qquad \begin{matrix} x^2=z^2-y^2 \\ x^2=4m^2q^2 \end{matrix}$$

$$\begin{cases} z+y=2m^2 \\ z-y=2q^2 \end{cases} \qquad \begin{matrix} x=2mq \\ x^2=z^2-y^2=4m^2q^2. \end{matrix}$$

Any factor common to y and z would be common to $2m^2$ and $2q^2$, but m and q are relatively prime and the only possible factor of y and z is 2. m and q being relatively prime both must be odd or one is odd and the other even. Suppose m and q are both odd:

$$(2) \quad \begin{cases} m^2=4n_0+1 \\ q^2=4n_1+1 \end{cases} \qquad (6) \quad \begin{matrix} z=m^2+q^2=4(n_0+n_1)+2 \\ y=m^2-q^2=4(n_0-n_1)+2. \end{matrix}$$

Then z and y both have the factor 2. If m and q are both odd z and y would have the factor 2, and we would not have a primitive solution. Therefore, for m and q to be relatively prime, one must be odd and the other even.

Conditions for a Primitive Solution

(1) m and q must be relatively prime.
(2) q must be less than m (6).
(3) For values of m and q, one must be odd and the other even.

Some Primitive Solutions

m	11	7	6	8	18	12	14	16	11
q	2	4	5	5	11	7	11	9	4
x	44	56	60	80	396	168			
y	117	33	11	39	485	95			
z	125	65	61	89	243	193			

Successful Practices and Provisions for Enriching the Educational Program for Gifted Students in Junior High School Mathematics and Science

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The word 'education' comes from the Latin word '*educere*' meaning to lead out or to bring out. Many schools throughout the nation have seen the need for improving the educational program for gifted students in mathematics and science in order to bring out the latent talent and provide for the optimal development of each individual. Plans and studies have led, in many instances, toward improved methods for providing more adequately for academically talented pupils. Beginning with a modest program at the beginning, schools have expanded their educational programs for their capable pupils in mathematics and science to the extent that worthy progress is evident. The concern with the problem of providing better educational programs for gifted pupils appears to be omnipresent. Teacher training institutions in many states have added new courses which deal specifically with the education of the gifted student. National organizations have provided leadership in this area and have devoted many pages in their respective periodicals and magazines to the topic of the rapid learner. Administrators have given serious attention to provisions for individual differences on the part of pupils in their schools in the form of curriculum changes and the initiation of new learning activities. Teachers have put forth considerable efforts to improve learning opportunities for the gifted pupils in their charge regardless of the organizational pattern of their particular schools. Parents in many communities have become actively interested in, and concerned about the educational programs in schools in their area and are asking if the school program really is meeting the needs of all the pupils. The nation as a whole has become aware that providing adequately for gifted pupils is an important project for our nation.

> The maximum welfare for a group is achieved when each member contributes as much as he is able. . . . The democratic ideal can be most fully attained when every individual has opportunity for educational experience commensurate with his abilities and for vocation responsibility commensurate with his qualifications.[1]
>
> The future of our contry and of democracy as a way of life depend to a considerable degree upon the widespread recognition and development of our greatest resource—gifted children and youth.[2]

Of course, one can point to schools where little or no progress is

[1] Educational Policies Commission, *Education of the Gifted*, NEA, Washington, D. C., June, 1950, p. 2.

[2] Paul H. Witty, "Today's Schools Can Do Much for the Gifted Child," *The Nation's Schools*, 1956, Vol. 57, No. 2, p. 72.

being made in providing for gifted pupils in mathematics and science. Much progress is being made in a great many schools, however, in attempts to develop adequate gifted-pupil programs. Many successful practices and provisions are being used to bring out the fullest development of capable pupils. By successful practices is meant those activities which teachers have reported as valuable ones for helping them develop further insight, interest, and initiative, for talented pupils in mathematics and science in the junior high school.

This article is concerned with the discussion of specific enrichment practices and activities for the gifted pupil in junior high school mathematics and science. Activities which have been used successfully by teachers in many states will be mentioned in both mathematics and science. It is quite obvious that one could not exhaust all of the valuable activities now being used to provide more adequately for the talented pupil in junior high school mathematics and science, nevertheless, it is hoped that the reader will be able to find some ideas and techniques which will be of value in his teaching situation.

Enriching the Learning Process

An effective enrichment program is concerned with enriching the pupil's entire learning process. Foster E. Grossnickle points out clearly four objectives of enrichment in his article entitled, "Arithmetic for Those Who Excel," when he says: "Four major objectives of enrichment are: (1) To encourage students to work independently and learn directly from appropriate books and periodicals, (2) To enable students to develop broader skills and to acquire more technical knowledge than the average student can assimilate, (3) To give the student the opportunity to explore, discover, and develop his interests and potentialities, . . . and (4) To challenge the student to work at the level of operation at which maximum growth . . . is possible."[3] The true enrichment process does not include merely the addition of extra work for the pupil concerned, but aims to enrich the pupil's entire learning process in mathematical and scientific pursuits.

The Enrichment Unit. One enrichment provision which appears to be gaining increasing use throughout the nation is the 'enrichment unit' in mathematics or science. Such units are designed for developing greater insight, interest, and motivation in science and mathematics on the part of capable students. Such a unit can be used as supplementary to the regular classroom work; as a specific unit within the course; or in mathematics or science clubs and other activities not necessarily connected directly with the work in the classroom. One seventh-grade pupil in a junior high school in Lincoln, Nebraska, became interested in a self-teaching unit on the binary system which her teacher has asked her to study after comple-

[3] Foster E. Grossnickle, "Arithmetic for Those Who Excel," *The Arithmetic Teacher*, 3: 41.

tion of the daily assignments. Testing revealed that this young student had gained considerable knowledge about the work in the unit and she was asked to present a short talk to the entire class on the topic of the base-two number system. This activity led to a presentation about the binary system by this gifted pupil to a ninth-grade algebra class in the same school. Subsequently, this seventh-grade girl was invited to speak on the binary number system to a college mathematics class at the University of Nebraska. Aside from the interest this pupil developed for others in the unit on the binary system, this experience was truly an enriching one for her. Not only did she gain considerable knowledge about the binary system, but a new interest developed in the use of other number bases and a greater appreciation for the decimal system on the part of this pupil was evidenced. Other enrichment units in mathematics for the junior high school level now in use are entitled, "Logic," "Men of Mathematics," "Pi," "Number Bases," and "Mathematical Recreations." Teachers and administrators will be able to think of many other topics worthy of development into enrichment units for their mathematics and science classrooms.

Developing Creativity Through Writing Experiences. Developing creativity is paramount when working with pupils gifted in mathematics and science. Activities involving written and oral expression frequently are used by teachers to foster the creative talents their pupils possess. In one school system consisting of six junior high schools, teachers encouraged talented pupils in their mathematics and science classes to write articles on topics of special interest and submit them for possible publication in the school system's junior high school *Mathematics and Science Newsletter*. Some of the pupils' articles were written as class projects; some were written as out-of-class assignments; and others were written through clubs or other activities not directly concerned with a special course. Completed articles were sent to a central office for editing by the editorial board which consisted of three junior high school teachers. The accepted articles were published ultimately in the publication mentioned above. The mathematics and science paper was then distributed to all pupils in mathematics and science classes in the six junior high schools so that everyone could benefit by the many fine articles which were included. Some of the articles written by these junior high pupils and included in the publication were entitled, "Opportunities in Science and Mathematics," "Pi," "How to Use the Slide Rule Correctly," "Distances that Defy the Imagination," "The Binary System," "Gauss," and "What is a Scientist?" Teachers involved in this project reported that this activity had been received with a great deal of enthusiasm. The project had given their pupils an opportunity to be creative in many ways. Teachers of gifted pupils in

mathematics and science are using many other activities in creative writing for the purposes of increasing the interest and presenting new challenges for these pupils. In one instance, an article written by a seventh-grade boy was submitted for consideration by the editors of *The Arithmetic Teacher*. The article was accepted and published in the December, 1956, issue of the periodical. Many teachers have pointed to the use of writing experiences that provide opportunities for research on the part of the pupil. Information and findings revealed by the research projects are summarized in written form by the student and then discussed by the entire class. Some teachers have had class projects which have led to the formation of a class paper on topics dealing with mathematics and science. The activities in this area which can be of value in fostering the creative talents of gifted pupils are practically limitless. Teachers, of course, are using many other worthwhile activities in this area that have not been discussed in this article. Illa Podendorf points out the responsibilities of teachers for the development of creativity on the part of all pupils in the following statement:

> It is our job as teachers to help children gain command of sufficient background and to gain it in such a way that they will get experience doing something which in their experience has never been done before. They need the practice and the thrill of putting ideas to work and coming out with new ideas and achievements. Not every child is equally creative, but every child can profit from experience in using creative abilities which he has.[4]

Mathematics and Science Projects. Both individual and group projects in mathematics and science frequently are used for furthering pupil interest and development in specific areas in these fields. In some instances, completed projects are displayed within the classroom. Frequently, exhibits and projects are collected and sisplayed in a central location for pupils, parents, and others to see. One school used (for presenting an educational assembly for the entire student body) displays and exhibits completed by talented students in the school. Each pupil displayed his project before the audience; answered questions concerning the exhibit as he described the nature and significance of it; and told how his particular project had helped him to develop a better understanding of mathematics or science. Teachers and pupils indicated that the activity had been extremely successful. On many occasions, pupils' exhibits or projects are photographed, described in written form, and entered in contests or programs in mathematics or science such as the Future Scientists of America Contest which is conducted annually. In all such activities, the challenge and self-motivation which accompanies the pupil's efforts enriches the learning process.

Developing an Atmosphere for an Exchange of Ideas. The impor-

[4] Illa Podendorf, "Creativity in the Teaching of Elementary Science," School Science and Mathematics, April, 1958, p. 286.

tance of encouraging pupils in mathematics and science to share ideas, opinions, solutions, and methods with others in the classroom is paramount. The promotion and development of a democratic atmosphere in the classroom in which each pupil has an opportunity to plan, carry out, and evaluate activities in mathematics and science is essential in any gifted-pupil program. In a survey taken in one junior high school, gifted students were asked to name the one teaching technique they felt had helped them most: (1) To learn new subject matter, (2) To maintain an interest in the class work, (3) To challenge thinking, (4) To develop new ideas, and (5) To foster an atmosphere conducive to learning. Although many methods were mentioned, the majority of students named the use of the panel discussion as the most valuable for them. The panel discussion was a method used by one science teacher each week for fostering an atmosphere for the cross-exchange of ideas and knowledge. In some instances, the panel served the purpose of summarizing and emphasizing the week's work. On other occasions, research problems were discussed, objectives were determined, findings were presented, and evaluations were made. Many variations of the panel discussion technique could be used in mathematics and science classes for bringing about a stimulating exchange of ideas and opinions, promoting an atmosphere of cooperative planning and evaluation, developing critical thinking and creative organization, and providing a challenge for learning. Some teachers have pointed to the value of the seminar method in classes of gifted pupils; others favor the well-known oral-report method. In any case, such techniques as the ones mentioned can be of value in enriching the learning for capable pupils in mathematics and science, for such activities provide opportunities: (1) To promote goal-directed activity, (2) To foster a sense of responsibility on the part of each individual, (3) To develop the abilities of pupils to work cooperatively with others, (4) To improve upon techniques of self-expression, and (5) To encourage the development of logical thinking on the part of each pupil.

Other successful enrichment activities now being used to provide more adequately for gifted students in junior high school mathematics and science include the following:

1. Assignment of additional exercises and supplementary problems. Intelligent assignments of such problems and exercises can be of value in developing in capable students further interest and insight in various phases of mathematics and science.
2. Applications of Mathematics and Science. While many teachers point out the necessity for showing the practical uses of mathematics and science, others indicate the need for allowing gifted pupils to work abstract problems in these areas simply for the 'sake of mathematics and science.' Many teachers feel that mathematics, especially, is a subject in which practicality is not essential. These teachers point to the many developments in mathematics which had no real practical application at first. Others point out

that pure mathematics is not concerned with practical application. Many hold the point of view that science and mathematics are self-motivating for gifted students and therefore the introduction of practical applications is not necessary.

3. Mathematics and Science Clubs and Organizations. Mathematics and Science clubs and organizations are being used in many schools to develop interest and further learning for gifted pupils in these fields. Such clubs give the pupil an opportunity to participate in activities of special interest that might not be feasible in the regular classroom. Frequently, unique and valuable research projects are carried on in science or mathematics in such groups; exchange of ideas runs high and new learning is almost inevitable.
4. State and National Contests in Mathematics and Science. State and national contests apparently are being used in many schools to help challenge and encourage gifted pupils. In one school in South Dakota, mathematical and scientific contests are held regularly with other schools in the state. Contests consist of written and oral examinations and are much like athletic contests, in that winning schools are named and individual standouts honored. Teachers reporting the use of this activity say that the atmosphere accompanying it is excellent. All feel that the idea carries with it an air of good feeling between individuals and schools; gives the students a chance to develop more fully their mathematical and scientific potentialities; and results in renewed interest in classroom work on the part of all concerned. One pamphlet which might be of value to the reader in finding out more about such national contests, scholarships, institutes, and so forth is The Future Scientists of America Foundation's compilation in their booklet, "Encouraging Future Scientists—Materials and Services Available," available through the National Science Teachers Association in Washington, D. C.
5. Extended Library Services. A responsibility of teachers and administrators alike is that of providing adequate resource materials in reading for their talented students in mathematics and science. Several writers point out that one major reason that libraries are inadequately supplied with good reading materials for gifted pupils is that librarians do not really know what books teachers want ordered. This fact points to the need of teachers working closely with the administrators and librarians in order that needs are known and an adequate mathematics and science library can be established. If pupils are made aware of the literature available, many will read quite widely on topics which otherwise might have escaped their attention altogether.

Many other specific enrichment activities in mathematics and science could be mentioned at this time. However, it would be impossible to discuss all of the fine provisions presently being used to enrich the learning process for gifted pupils in mathematics and science classes throughout the nation. An attempt has been made to discuss some of the latest provisions for capable pupils in these two fields. Perhaps this article includes some ideas which other teachers and administrators will find applicable to their own program for gifted pupils. Although progress is being made in this area, much more is left to be done. But as in the past, teachers, administrators, parents, and others interested in the welfare of our youth and the nation will meet the challenge and continue to build better programs for our future scientists and mathematicians.

Why Do Scientists and Engineers Join the Staff of the Argonne National Laboratory?

W. Charles Redman

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The ever-rising standard of living enjoyed by our nation is due, in a large measure, to the exploitation of our abundant natural resources. The most important resource, the key to proper use of our other resources, is the human mind. In recent months, much attention has been given to the need for attracting a larger fraction of eligible young people into scientific and engineering professions. Several independent groups are actively engaged in an evaluation of the current practices in technical education. Much less attention has been given to the problem of enhancing the contributions of those actively employed in the technical professions.

I would like to emphasize that training for a technical profession begins in earnest following completion of high school, but only about ten per cent of the potential professional life is spent in the acquisition of academic degrees.

Industrial and business organizations owe a tremendous debt to our colleges and universities for the production of technically trained personnel, but ideally the process of education is never completed. Thus the basic problem is to provide an environment commensurate with the effective utilization of graduate scientists and engineers to assure that professional development continues throughout the working life of the individual.

For an organization to gain the highest degree of efficiency, it must use its skilled manpower wisely and effectively. We all recognize that improved efficiency and productivity of an organization is premised on contributions from, and, hence, the abilities and attitudes of employees toward their respective assignments.

The first step toward effective utilization of technical personnel is the elimination of stockpiling and misuse of their intellectual potential, and their assignment to activities for which they are mentally and physically suited. Stockpiling in anticipation of future need is a situation which is definitely limited, if not eliminated, by economic considerations.

It is my opinion that misuse of technical personnel is not as prevalent as is normally supposed. Much concern is expressed over the diversion of science and engineering graduates into sales, management, supervision of production, time and motion studies and the like. However, I believe that the attitude that must be taken is that these people have found a situation wherein their educational background is utilized in a manner consistent with their special interests

and capabilities. An analogous situation exists in regard to formal training for the legal profession. Only about half of those possessing law degrees are actively engaged in the practice of law. Rather it provides a very useful background for a variety of business activities. Substitution of the term engineer results in an equally valid description of the existing situation.

Environment

The term environment describes the totality of external conditions and influences affecting the life and development of a person. Long before an individual acquires professional employment, a tremendous variety of influences have served to mold his character, interests and aptitude. Furthermore, since less than half his waking hours are confined to job-related activities, his social, religious and civic contacts, and probably most important of all, his relations with his family, all exercise an important influence on his technical productivity. Although it represents an unrealistic oversimplification of the effect of environment, I propose to limit my remarks to the important influences directly affecting the professional performance of an engineer or scientist and give scant consideration to factors external to his specific "on-the-job" environment. To avoid an abundance of either generalities or qualifications I shall confine my attention to the situation of a scientist or engineer engaged in research or development activities.

Dominant Factors in Job Selection

A knowledge of what an engineer or scientist considers as desirable characteristics of a position provides an insight into his motivation and thereby a clue regarding the means for increasing his effectiveness. I am indebted to forty-six of my colleagues who provided, unwittingly, the information which will make my remarks less subjective.

Recently our Personnel Department conducted a survey among the eighty scientists and engineers added to our staff to fulfill the requirements of an expanded research and development program. Intensive competition for the limited number of technical personnel available throughout the United States provided a good situation in which to evaluate the factors which prompted their choice of employment. To each new employee was addressed a simple questionnaire formulated to give the individual adequate opportunity to express his reasons in his own words. The more common reasons given by the forty-six who returned the questionnaire were:

Interest in work	26
Proximity to Chicago	17

Equipment and facilities	14
Professional associations	11
Work conditions	11
Salary	11
Opportunity for development	11
Month vacation	11
Suburban location	10
Benefits	10
Atmosphere	9

I wish to comment on each of these reasons as a significant factor contributing to the job environment. For convenience, I have grouped these reasons into five categories of approximately equal importance, as measured by the response. These are location, facilities, remuneration, job, content, and professional climate.

Location

This category includes the reasons stated as suburban location and proximity to Chicago. Since the desire for suburban employment (and residence) is not at all peculiar to the technically trained individual no further comment is required here. The large number mentioning the latter was not anticipated, and so further elaboration was requested. The response revealed that family ties in the Midwest, usually the wife's, were an important factor in the selection of employment. The implication is that the technical force is not as mobile as heretofore has been supposed. The expected explanation for the choice on the basis of location, namely convenience to abundant cultural and recreational activities, was not an important factor.

Normally the location of a technically staffed organization is not readily changed, but I would like to make two brief comments regarding location as a factor to enhance the contentment and hence the productivity of a technical man. A casual perusal of the advertisements which fill our technical publications today will show that those industries in a position to offer a particularly attractive location are well aware of its appeal. On the other hand, the influence of family ties should offer encouragement to those employers whose plants are not favorably located.

Facilities

Here I have grouped for consideration the reasons tabulated as equipment and facilities, and working conditions. The degree to which equipment and facilities exist for research and development, and the working conditions for the professional personnel represent a tangible means for assessing the role of technical activity in the functioning of an organization.

The existence of specialized equipment for technical work indicates a history of availability of funds and thus is indicative of the attitude

of management on the long-range value of technical activities. Since money expended in this manner is considered a business expense, there is little reason why an organization seriously convinced of the value of research and development has not provided adequate facilities under the present high tax rates on business profits.

Working conditions include the availability of adequate assistants to relieve the scientist or engineer of para-technical tasks. This is an important point in regard to effective or increased utilization. The availability of technicians, editorial assistance, and adequate clerical and administrative personnel is a measure of the degree of utilization by a particular organization.

Unlike the situation regarding location, the provision of adequate facilities and supporting personnel represents a means readily available to management for the attraction and more efficient utilization of its technical personnel.

Remuneration

Here I consider reasons stated in terms of salary, benefits and length of vacation. It has been often stated that salary is a minor motivator when applied to scientists and engineers. Certainly to a scientist or engineer other considerations are at least as important as remuneration in establishing whether he is satisfied with his status; however, whether a scientist, engineer, or layman, a person faced with financial problems will not function effectively on any job.

The engineer or scientist requires a certain minimum income for mere subsistence, and generally the effect of his education and social associations has been to develop a desire for a higher standard of living, particularly in regard to comfort, recreation and education of his children. The economic and social status of technical personnel has suffered markedly in recent years, primarily because of a failure to educate the public to a recognition of their contribution to our economy. The lot of educators has suffered in an even more drastic manner. In both cases the result has been that remuneration no longer plays a minor role in regard to satisfaction with working conditions.

To some extent the salary structure for technical personnel within an organization reflects the attitude of management in regard to their value to the organization, but perhaps the determining factor in regard to salary scales is the fluctuating degree of competition for the available supply of personnel. One item of extreme dissatisfaction on the part of experienced technical personnel is the limited spread in many organizations between starting and maximum salaries. This problem has been treated in some detail in other papers.

Job Content

An interest in the work was the reason given most frequently in the survey. This means only that some phase of the current technical program appealed to the individual as being consistent with his training, interests, and aptitude. A further consideration of much importance is that the technical person be allowed to at least select if not recommend his assignment within the framework of the existing and future programs. There is an infinite variety of challenging problems in the field of industrial research and development and so it should not be difficult to provide this flexibility of activity for a qualified employee.

Every scientist or engineer derives tremendous satisfaction from seeing the results of his activities carried through to fruition in the form of a useful contribution to our technology. If management is responsive to its opportunity, a significant increase in productivity of professional personnel is achievable by a small amount of effort in informing these employees of the reasons underlying the technical program, the specific objectives and expected accomplishments.

Professional Climate

So far I have reviewed those motivating factors whose existence or means for achievement are readily discernible. The final and most important incentive for increased productivity by the technical man is the immediate professional environment. This is composed primarily of two factors: his professional associates, and the attitude of management toward his technical growth. In regard to the first factor, the constant association with fellow scientists and engineers enriches the professional life through a process of mutual stimulation and intellectual cross-fertilization. The effect of management's attitude results from an inherent American tradition of personal freedom as it affects self-expression, self-development, and arbitrary control.

The importance of professional associations has its foundation in experiences at the start of the professional career. In academic surroundings the embryonic engineer or scientist is filled with a knowledge and appreciation of the gradual development of scientific thought, its application to technical problems confronting humanity, and its contribution to the material betterment of his fellow man. Through close association with the learned men gathered as instructional and research faculty at his college or university he learned to appreciate their vast knowledge of and contributions to science and engineering. This served to stimulate in him a desire for more knowledge, and unconsciously, he developed an intellectual bond with these outstanding scientists and engineers of his acquaintance.

Consider now this individual's transition from the intellectually-stimulating atmosphere of the campus to employment with an industrial organization which considers the technical man only as a tool for improving its specific products and widening the margin of profit. His role is that of a "trouble-shooter," assigned immediately to a drawing board, a production line, repair ship or a sales and service department. Suddenly he has found himself removed from a world where pursuit of knowledge is the primary objective and thrust into an organization where he is a small cog in a tremendously complicated machine, subservient to production and profit. In such an atmosphere his ambition and initiative would be rapidly destroyed. I hope that this picture describes a totally unrealistic situation.

Contrast this with the situation which could exist in a well-managed, forward-looking organization. The new technical employee is added to the staff because in him is recognized the promise of important contributions over the years of his working life. Consequently, much attention is paid to a thorough orientation in regard to the organization and objectives of the company. He is given an opportunity to acquire a first-hand knowledge of the role of technical personnel in the company through successive assignments in a number of departments. He is encouraged to continue his education either through existing on-the-job training courses or enrollment at a nearby university. He finds that the organization actually helps him to continue development in this manner through released time, reimbursed tuition, or some similar plan. He notices that this associates, who have experienced a similar orientation in the past years, work with enthusiasm and intense interest on assignments which offer a continuing challenge to their growing capabilities. His immediate supervisor not only is always willing to discuss his work, or any other problems, but actually feels that this is his primary function within the organization. Adequate assistants, such as draftsmen, computers, purchasing agents, editors and secretaries, are available and anxious to assist him in fulfilling his assignments. His performance is reviewed frequently and appropriately rewarded. As he acquires new knowledge and skills, his succeeding assignments provide commensurate challenge and, in growing measure, his work is self-directed.

The situation just described depicts an ideal toward which management must strive if it is to achieve maximum utilization of technical employees. Not only must management be efficient in utilizing to the utmost the present abilities of each employee but there must be a constant and concentrated effort to develop each employee to the limit of his capabilities. When an employee finds that the challenge of his job assignments increases with passing years he will be anxious to exert himself to prove that he is capable of meeting these challenges; the successful completion of each assignment will enhance

self-confidence and instigate enthusiasm for further growth. Such an attitude is contagious and cannot help but contribute significantly to the intellectual atmosphere and future growth of the entire organization. Obviously the success or failure of an organization to properly utilize its scientific and engineering talent depends directly on the attitude of management toward the importance of their contribution and a recognition of the increased benefit to be derived from continued professional development of its staff.

Much of the intellectual stimulation so prevalent in an academic atmosphere does exist in some of the large technical groups associated with industry, but even the smallest can achieve some measure of the intellectual atmosphere so conducive to maximum productivity on the part of technical professionals. Attendance at technical meetings, loan of employees for specialized instruction in nearby colleges or universities, and the hiring of professors during their vacation periods would do much toward creating the same atmosphere within a smaller organization.

As with most things, the creation of an academic atmosphere within an organization can be overdone. Profit from knowledge rather than knowledge itself must be at least the long-range objective of the technical activities of an industrial organization. Achievement of this objective is best accomplished by a sustained effort to increase the capabilities of the technical staff through provision of the type of environment most conducive to professional growth. The gain accruing from increased productivity will far exceed the cost of providing this favorable climate.

SUMMARY

Attention has been focussed on several topics which represent the major reasons why scientists and engineers choose a particular position. The reasons motivating their choice are identical with those factors which will serve to assure a high level of productivity for the duration of their professional life. The circumstances required for maximum utilization of technical talents are readily achieved within almost any organization. The executives and administrators responsible for the formulation and interpretation of policy must be made aware of the nature and needs of technical personnel if an environment conducive to effective performance is to become a reality.

SCIENTISTS PROBE MATTER AT VERY LOW TEMPERATURES

The properties of matter at very low temperatures, some 459 degrees below zero Fahrenheit, are being probed by scientists around the world.

Their studies are aimed at a better understanding of how atoms are held together but they may also yield new and cheaper methods for transmitting electric power.

Measuring Progress in the "Doing" Skills

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Over the past years and especially during the recent ones many deficiencies in science teaching have been brought to the attention of educators and the public. One of these shortcomings has been that of testing and evaluation. Mallinson[1] in 1954 listed the need for testing the methodology of science rather than facts as one of the "five most needed research investigations in the teaching of science." This need still exists today.

Since the introduction of science in the schools, one of its major objectives has been to develop scientific thinking. There is general agreement that scientific thinking can be developed only when the student has scientific experiences during which this activity is practiced. Further, it is reasonable to assume that the measurement of the attainment of this goal must be accomplished by measuring the skills involved in such thinking.

Yet the testing of scientific thinking has been hampered by the fact that little has been done to articulate in words of one syllable what constitutes scientific thinking.

One recent effort has been that of the Michigan Science Teachers Association[2] in which these skills are defined in terms of what a student should "do" better as a result of his study of science. The "doing skills" as set forth in this report are as follows: (1) to observe objects that exist, and the phenomena that take place, in the environment and to report accurately what is observed; (2) to compare objects and phenomena with respect to their likenesses and differences; (3) to evaluate the relative importance of information and the relevancy of the data that is obtained through observation; (4) to determine if enough information is present to warrant a tentative or conclusive answer; (5) to determine the kind of information still needed to warrant an answer if information is lacking; (6) to decide on the most efficient way of obtaining the needed information; and (7) to carry out experiments with the materials at hand if such an experiment is necessary to gather the needed information.

Whether or not the "doings" are valid objectives of science teaching may be a matter of question. Yet they seem to offer an opportunity for evaluating scientific skills better than other statements of objectives.

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[1] Mallinson, George G., "The Five Most Needed Research Investigations in the Teaching of Science," SCHOOL SCIENCE AND MATHEMATICS, LIV (June 1954), 428–30.

[2] "Content and Emphasis to Implement the Curriculum Structure for Science Teaching in Michigan." *Newsletter of the MSTA*, VI (July 1958), 8.

Before constructing measuring devices for these "doings," however, another problem must be considered. Research has shown that students express dislike for tests requiring the application of principles to specific situations and those necessitating a discernment of relationships.[3] The task of the teacher thus becomes one of preparing the student, through day by day exercise, to apply knowledge gained in his classwork to his daily life and to discern relationships existing between his environment and the principles he has learned in the classroom. The test should, therefore, be consistent with classroom procedure.

In constructing a testing device, certain other basic considerations must be made. One of these involves the type of item on the test. Test items may be of the free-response type—essay, short answer, or completion; or of the limited-response type—matching, arrangement of items, true and false, and multiple-choice. In examining the possibilities of these various types of items, it should be pointed out that the free-response types offer the greatest difficulty in scoring. The limited-response types, on the other hand, by limiting the answers to a choice of listed responses are scored more easily.

Each type of test item, if carefully constructed, has its own merits. The New York State Bureau of Examinations and Testing[4] lists the following uses of the various types of test items: "The essay item can be used to measure higher level abilities by requiring pupils to present evidence, to evaluate, to analyze, and to solve new problems . . . in the completion item the emphasis is on recall rather than on recognition . . . true-false items can be used to measure reasoning and understanding . . . multiple-choice is used with the greatest effectiveness to measure reasoning ability and fundamental understanding . . . matching items measure the association of important and related concepts."

The mechanical features of the test are, of course, as important as the types of items used. Included under this category are item format, scoring arrangements, distribution of correct responses, grouping and arrangement of items, designating credit allowances, directions for answering questions, allowing choice of items, and printing and duplicating of the test.[5]

A second consideration is how "good" is the test? According to Adkins[6] the characteristics of a "good" test are: (1) its validity or

[3] Mallinson, Jacqueline Buck, "Relative Difficulties of Different Types of Items on Tests for High School Science." SCHOOL SCIENCE AND MATHEMATICS, LVIII (April 1958), 297–306.

[4] *Improving the Classroom Test: A Manual of Test Construction Procedures for the Classroom Teacher.* Bureau of Examinations and Testing, State Education Department, University of the State of New York, Albany, New York, 1958. Pp. 56.

[5] *Loc. cit.*, 54–5.

[6] Adkins, Dorothy, *Construction and Analysis of Achievement Tests.* Washington, D.C., U. S. Civil Service Commission, 1947. Pp. 292.

differentiation between the desirable and undesirable; (2) its sampling of all parts of a field with adequate reference to the importance of each part; (3) the reliability of measurement of abilities in a constant way; (4) its face validity or acceptance by interested persons; and (5) the ease of administering and scoring. It is obvious that a difficult task awaits the test developer as he endeavors to make a valid, reliable test.

A third consideration in test construction is the purpose of the test. By clearly defining and keeping in mind the purpose of a given test, the test developer has a goal for which to aim. One should also delineate the areas of knowledge to be included in the test framework.

Another consideration is, how does one construct test items? Assuming that multiple-choice items are to be used, these rules will act as a guide: (1) keep the item practical, realistic, important, and useful; (2) phrase the item in clear, accurate working language; (3) have the question demand knowledge of the task being presented; (4) keep each item independent of every other item so that no answers are given away; (5) introduce no irrelevant details into the question; (6) have the alternatives deal with similar ideas or data, and (7) don't give away the best answer by irrelevant details.

Once the characteristics and techniques of test construction are firmly in mind, it becomes the task of the writer to apply them in as comprehensive a way as possible.

If the object of the test is to measure "doing" skills, it is reasonable that a pattern of doing must be measured by the test items. For that reason, it is suggested that in the measurement of the "skill of observation" an object, description, or situation be provided and the student be required to observe the given item and record his observations in an accurate fashion according to a previously explained pattern. In the same way the "skill of comparison" could be tested by giving the student two items and asking him to compare the two, first, as to the ways in which they were alike and second, as to the ways in which they were different. The fact that the item to be observed and compared might once have been regarded as the absolute objective of the unit under discussion is purely incidental.

The "skill of evaluation of information" can be tested by providing an item with a number of different relevant facts concerning it and asking the student to determine the relative importance of each by placing them in order with the most important fact coming first and the least important fact coming last. This skill could also be tested by giving an item followed by a list of relevant and irrelevant information and asking the student to determine which is relevant to the problem under discussion and which is not relevant. He could also

be asked to rank the relevant material at the same time he is making his discernment.

The unit chosen as a sample unit is that entitled, "Living Things." The major objectives in the teaching of such an unit are to develop: (1) an understanding of the characteristics of all living things; (2) an understanding of the differences between plants and animals and their relationships to each other; (3) an understanding of the needs of all living things; (4) understandings as to the place of living things in their environment; and (5) the development of "doing" skills related to the scientific method.

The "trial" test follows:

To test to "determine if enough information is available" an item could be supplied with a complete or incomplete description. The student would then be asked to evaluate the item with its description and determine if further description is needed. This would also test to determine the student's ability to "determine the kind of information still needed."

Testing to decide if the student could "determine the most efficient way of obtaining the needed information" could be done by supplying a new item or using a previously used situation and giving the evaluator several possible sources of additional information. The pupil would then be asked to decide which of the methods listed was the most efficient.

If it were desired to test the student's ability to "carry out an experiment," this might be done by providing the student with an entirely unfamiliar problem and asking him to write down the steps he would follow in experimenting to find the answer to the problem.

Theoretically, any item on the test might be totally new to the person being tested. Yet, he would be able to perform adequately because of this knowledge of the "doing" skills of science. It would, of course, be more valuable in some instances to employ factual information for which one believes the student should be responsible.

Concrete evidence of a suggested procedure is always advisable. It is, therefore, the purpose of the remainder of this paper to consider the objectives of one representative area of the eighth-grade general science curriculum. In the light of these objectives a suggested test for the measurement of the "doing" skills will be constructed.

Any test has two definite aspects: (1) to tell the teacher how well the student has mastered a given topic and (2) to help the student evaluate his accomplishment in terms of what it should have been. It follows, then, that a test such as the following would not be given until the student has had sufficient practice in the utilization of the techniques involved.

FREE-RESPONSE TEST

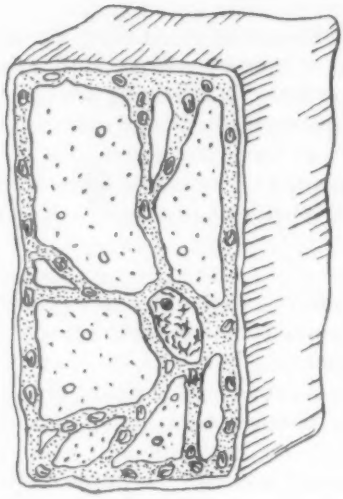

FIGURE A

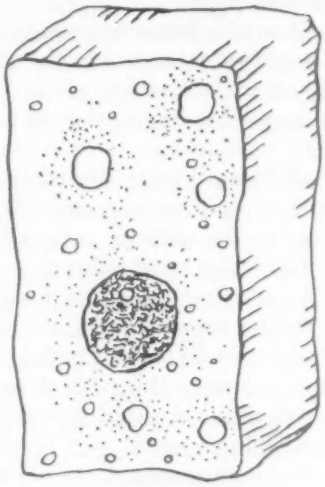

FIGURE B

1. a. Study figure A carefully.
   b. List all the items which would be necessary to describe it to someone else in so complete a way they would recognize it.
2. a. Compare figure A with figure B.
   b. List all the ways in which they are alike.
   c. List all the ways in which they are different.
3. a. Observe the small organism on your desk.
   b. Give your reasons for calling it a plant or an animal.
   c. To what group in the kingdom does it belong? Why?
4. Put the items which are necessary to make this statement complete in the order of the most important item first. Leave out any incorrect items.
   "Plants and animals are alike because . . . "
   a. they both need air.
   b. they live in the same environments.
   c. they are made up of cells.
   d. they both need food.
   e. they both have adaptations for protection.
   f. both can move from place to place.
   g. both make food when it becomes necessary.
5. Choose the correct items concerning the following statement:
   "Both plants and animals need . . . "
   a. light
   b. carbon dioxide
   c. oxygen
   d. water
   e. shelter
   f. protection from their enemies.
   g. certain temperatures.
   h. food
   i. minerals
   j. chlorophyll
6. Decide if the following description of an insect is complete. If not list the items necessary to make it complete.
   "An insect is an animal with legs, compound eyes, antennae, and sometimes wings. They change form or size during their life time."

7. If you wanted to find out the effect of sunlight on the growth of a mushroom plant, which of the following would you use as a source of information?
   a. textbook
   b. encyclopedia
   c. experiment
   d. someone's opinion
   e. a movie
   f. all of these
   g. none of these. (If you choose this answer, list the method you would use.)
8. If you wanted to know the number of young produced by the average fly in one season, you would use the following source of information.
   a. textbook
   b. experiment
   c. encyclopedia
   d. someone's opinion
   e. movie
   f. none of these (If you choose this answer, list the source you would use.)
9. Suppose you were asked to determine how much sunlight an ivy plant needed to grow well. Give the steps you would follow in finding the answer.
10. If you had the job of introducing plants and animals into a completely barren area with an average year around temperature of 70°F. and 5 to 10 inches of rainfall per year, what factors would you need to take into consideration in choosing the plant and animal species?

LIMITED-RESPONSE TEST

1. a. Study figure A carefully.
   b. Choose from the following list four of the items necessary to describe figure A thoroughly to another person. Circle your answers.
   1—colorless
   2—invisible to the unaided eye
   3—has a denser center portion called a nucleus
   4—is made up of a jellylike substance called protoplasm
   5—has denser chains of protoplasm within the nucleus called chromosomes
   6—is square in shape
   7—has a definite shape
   8—has a cell wall to contain the contents
2. a. Compare figure A with figure B.
   b. Choose the ways in which they are alike from the following list.
   c. Choose the ways in which they are different from the following list.
   1—colorless
   2—invisible to the unaided eye
   3—has a nucleus
   4—made of protoplasm
   5—has chromosomes
   6—has a definite shape
   7—has projections of protoplasm
   8—has a heavy cell wall composed of cellulose
   9—has an irregular shape
3. Choose from the following list reasons for calling the specimen either plant or animal.
   1—makes its own food
   2—has organs for the purpose of giving an awareness of the environment
   3—contains chlorophyll
   4—has an adaptation for capturing food
   5—is equipped for movement
   6—is capable of reproducing itself
   7—uses the process of photosynthesis
4. List the following items in order with the most important first.
   "Plants and animals are alike in these ways . . . "
   1—they both need air
   2—they live in the same environment
   3—they are made up of cells
   4—they both need food
   5—they both have adaptations for protection
   6—they can both move from place to place
5. Choose the correct items applying to the statement, "Both plants and animals need . . . in order to live."

1—light
2—carbon dioxide
3—oxygen
4—water
5—shelter
6—protection from their enemies
7—certain temperatures
8—food
9—minerals
10—chlorophyll

6. Decide if the following description is complete. If not rewrite the description so it is complete.
   "An insect is an animal with legs, compound eyes, a pair of antennae, and sometimes one or two pairs of wings. They change in form and size during their life time."
7. If you wanted to find the effect of sunlight on the growth of mushrooms, which of the following would you use as a source of information?
   1—textbook
   2—encyclopedia
   3—experiment
   4—someone's opinion
   5—movie
   6—all of these
   7—none of these (List the source you would use, if you choose this answer.)
8. If you wanted to know the number of young produced by the average fly in one season you would use the following source of information.
   1—textbook
   2—experiment
   3—encyclopedia
   4—someone's opinion
   5—movie
   6—none of these (If you choose this answer, list the source you would use.)
9. Suppose you were asked to determine how much sunlight an ivy plant needed to grow well. Give the steps you would follow in finding the answer.
10. If you had the job of introducing plants and animals into a completely barren area with an average year around temperature of 70°F. and 5 to 10 inches of rainfall per year, what factors would you take into consideration in choosing the plant and animal species?

Two tests covering the same information have have been provided. The free-response test might be a fairer choice for those unacquainted with this type of testing because it doesn't require as much discrimination in making a correct response. The limited-response test by requiring greater discernment on the part of the student could be used with a more advanced group.

Although these tests are designed for an eighth-grade science class, it should not be assumed that a similar form of testing couldn't be used at all levels and in all areas.

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A One Year Integrated Natural Science Course for Colleges, and Its Problems

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Among the recommendations of a "Self Study" committee of the University of Pittsburgh in 1953 was that the general college requirement of the three areas—Humanities, Social Science and Natural Science—be changed so that the student would have a greater breadth of experience.[1] The proposed method of achieving this was by organizing general integrated courses in each of these areas. These courses were to be known as the "Core Curriculum." At that time the requirements in natural science were (and still are) eighteen semester hours of credits, including one year of laboratory science. There is no attempt to spread these courses among more than one subject.

In 1955 a committee was formed of members of eight natural science departments to study the problem in that area and to construct one or more courses to meet the recommendations of the Self Study Committee. Some of these committee members entered upon the work with the understanding that the natural outcome of the committee's endeavors would be an adoption of the generally prevalent two year program—one year in physical and one in biological sciences —since this plan had been favored in the report of the Self Study Committee. Others started with a bias against this type of two year program. Still others were apparently without preconception as to what type of organization should be recommended, but did not greatly favor the idea of general integrated courses. As group, the committee preferred to work out its own solution to the problem within the restrictions placed upon them, and felt but little need for investigating the way other schools handle the problem, though reports on the Chicago and Harvard plans were heard.

Other multiple course plans such as the three year or three term physical-biological-earth science combination, and the two year experimental and descriptive science separation, received some attention but no support. Discussion soon became a debate between the advocates of a two year biological-physical split and its opponents. In this debate the "neutrals" of the committee aligned themselves with the opponents of the two year plan and declared in favor of a one year program.

One point of contention which continually intruded into the discussion was whether the course was to be for all students or just non-

[1] Report and Recommendations by the College Self-Study Committee—University of Pittsburgh, October 1953.

science majors. Some believed the former desirable; others that it was undesirable to the point of absurdity, regardless of the intent of the committee's directive. This matter was never agreed upon by the committee even after the completion of the course plans.

The important features of the one year integrated course eventually agreed upon were these:

It included some material from all the natural sciences, including psychology and mathematics.

It tried to emphasize principles rather than facts. Facts were not ignored, however, for much factual material was regarded as essential to further understanding.

It attempted to show *how* our knowledge is derived, rather than merely what our knowledge *is*.

It used a partly historical approach, laying a chronological background for each topic so that the student could approach the subject with something of the same viewpoint as his scientific predecessor. This approach allows more student discussion than is likely in the usual systematic courses where the student merely sits and listens.

Integration was achieved by merging each subject with the next by some natural connecting link.

The same instructor was to continue with each class throughout the year's course to insure continuity.

Regardless of other predilections of the committee members, there was almost complete agreement in a rejection of authoritarianism. The committee wished to avoid merely giving facts and current theories, or a course in *What Modern Science Teaches*. They wished to establish one in *Why Modern Science Teaches What It Does*, and *How Science Operates*.

Arguments for and against a Two Year Physical Science-Biological Science Sequence

In view of the prevalence of the Physical and Biological Science courses in American colleges at present, it may be of interest to consider the various arguments which were made against them. They are listed here with counter-arguments.

1. Any split of subject matter violates an overall unity of sciences which should be stressed rather than played down. It is of dubious value to impress students with a bifurcation of natural science.

REPLY:

Such a bifurcation simply reflects a real split in the interests and methods of scientists. It is often said that physical and biological scientists do not speak the same language.

2. A split of subject matter may cause waste of time on concepts which are common to science in general (e.g. explanations of scientific method); or it may cause their omission because each course may consider that they are or should be treated in the other.

REPLY:

If one of the courses were prerequisite to the other this is not likely to happen. Even so, any repetition of subject matter important enough to be in both courses would not be "lost" time.

3. A two year sequence would prevent the non-science majors from taking the usual laboratory course except as an elective. A two year course would take up 12 to 16 of the 18 semester hours required in natural science at the University of Pittsburgh, and it was not anticipated that third full year of laboratory science was to be added to the other two for non-science students.

REPLY:

There is no reason why either of these courses could not be made a laboratory course if desired. However, there is some doubt that a laboratory course is of real value to non-science majors anyway.

4. A two year sequence may make it difficult for a student who becomes interested in a scientific career during his second year to work out a major without loss of time.

REPLY:

In most cases it can be done if all one's general education requirements in other fields are cleared in the first two years. And there will be very few cases of students choosing a scientific career at such a late stage. Practically all pre-science students choose their vocation before entering college.

5. The courses of the two year program would probably be somewhat systematic in treatment and contain some duplication with high school science. Students with a good high school background in physics and chemistry may with good reason wish exemption from a physical science course and miss the astronomy, geology, and whatever general material is there.

REPLY:

A good physical science course will contain much material in physics and chemistry, which even the well prepared high school graduate may profit by taking.

6. Some schools allow students a choice of one of the two courses,

contrary to the "core" idea. In such cases the biological science course is preferred to the physical science to an extent amounting to an abandonment of the latter.

REPLY:

This should not be permitted. Both courses should be taken.

7. One additional course may be difficult to work into the crowded schedules of some of the science majors. Two will be still worse. Some departments will vigorously oppose their majors taking both courses. But if the "core" is to be a real one, *all* students should take it. Exempting the science student from his "own" core course is not an answer since it means that the student may have a definite deficiency in knowledge closest to home, so to speak. For instance, why should physics and chemistry majors, of all college students, be excused from any contact with astronomy and geology? If these subjects are of no value to them, why should they be to anyone?

REPLY:

It is probably an error to excuse students from the core of their own area, but even if they are excused, they get a better spread than under the old system, where the physics and chemistry major would get no biological sciences.

8. The biological sciences course as usually given is a good, thorough, well integrated course, since it is nearly identical with the usual first year biology course, containing few or no topics extraneous to such a course. The addition of psychology might disrupt this normal pattern. Such a course would be something of an innovation. There are no existing texts which include psychology as part of a biological sciences course. In forming such a course there might be a tendency for biology to hold that psychology, being only one of the biological sciences, must take its place among zoology, botany, bacteriology, physiology, anatomy, and occupy no more of the course than any of the others. And psychology might well consider itself entitled to no less than half the course.

REPLY:

This insinuation of departmental rivalry does an injustice to the departments concerned. There is no reason why an excellent biology-psychology course could not be presented harmoniously.

9. The usual physical sciences course is not a good one because geology is a discordant element. Instructors with a background of physics, chemistry or astrophysics are often unable to appreciate or even understand geological methods and principles. If geology is

omitted, the course becomes more unified, but also more unyieldingly mathematical and forbidding to those students who have acquired a dread of the more rigorous sciences. It is true that the more precise aspects of geology which merge more directly with physics and chemistry may be chosen for the course, but geologists regard such topics as not belonging at the elementary level. Geology is not well placed in any divided science course. It is not properly a physical science any more than it is a biological science. Wherever it is placed it feels the need of accompanying material from the other course.

REPLY:

Geology *is* a physical science and good integration with the other physical sciences can be made. Geologists may be wrong in playing down the quantitative phases of the subject at the elementary level, but even in its descriptive aspects it provides a relief from the rigors of the other physical sciences in the course, and is not out of place.

Arguments for and against a One Year Integrated Science Course

The advantages claimed for the one year plan, stated in a positive form, are these:

1. It can accomplish the really important goals of a science core just as effectively and more economically than a two year program. These are, to impart information on and understanding of, such topics as the following: (a) How data or "facts" are obtained. (b) The meaning and reliability of hypotheses and theories; their part in the advance of knowledge. (c) Methods of scientific investigation, and ways of thinking in the various scientific disciplines. (d) The historical development of science and its impact on society. (e) What the various sciences are; how their fields differ and overlap. (f) Some of the important scientific concepts of today.

2. A one year course is unlikely to become so involved in subject matter as to lose sight of more general goals. This can happen in any course, but is more easily avoided in a one year than a longer sequence. The more specific a course is, the more it tends to merely stress the results of accumulated experience in the field covered.

3. A good integration of sciences is facilitated. There are no restrictions on the placement of subject matter within the course. Topics may appear where logical development demands.

4. The one year course should prove sufficiently valuable to the science major to make it worth adding to even the most crowded program. These benefits are:

(a) Some knowledge of all sciences, avoiding the one-sidedness of the normal normal education of the scientist of today.
(b) A knowledge of general scientific principles and methods of attack which may not be completely exhibited in the student's major science, but which may be of value in that field nevertheless.
(c) It will act as an orientation in one year. Students professionally interested in science can discover quickly what branch interests them most. (As it is, most students who become interested in science in high school naturally gravitate into the fields of their high school experience.)

5. When a student finds that he is interested in science, it is not too late to switch to a science major if the science core is a freshman requirement. Contrary to the general belief of physics and chemistry teachers, all science majors are not divided at the pre-college level. Majors in the non-high school sciences, geology and psychology, are interested at a later stage in their career, and some converts to the more basic sciences may also be made.

6. Non-science students will get a chance to make an intelligent choice of what laboratory science to take. They should also have an increased awareness and appreciation of the meaning of laboratory work and derive some benefit from it, instead of doing it in a slapdash way to get rid of it.

7. There would be no duplication with high school science, and no reason for students to be excused from the course because they have had more science experience in high school; though such students would have some advantage just as they do in similar circumstances elsewhere.

8. As long as the first year course is not considered as fulfilling the laboratory requirement, there will be no necessity for adhering to a regular schedule in the laboratory work. It is more effective if done sparingly and when *a propos*.

9. If a student is allergic to the more rigorous sciences, there is enough of the descriptive to prevent that "lost" feeling, and he may be encouraged to try to conquer the more difficult part also.

10. Fundamental questions cannot be avoided in this course. In other types of courses many matters are dealt with by referring the student to other courses which he should have had or will probably have in the future. Topics such as the relation of science to technology, the relation of science and technology to contemporary civilization, science and warfare, science and religion, are better discussed in a unified course than in a divided course.

Criticisms of the One year Integrated Course in Action

The reader may decide for himself as to the merits of these argu-

ments for and against the one and two year programs. Though these arguments appeared in committee discussion, it is not claimed that it was by their force that the neutral members swung to favor the one year program. It is feared that the reason of some may have been that inasmuch as integrated or survey courses are a waste of time anyway, it is better to waste one year of a student's time rather than to waste two! It must be acknowledged that since Pittsburgh is a refuge of the tradition of separate introductory courses, many of the faculty had little previous acquaintance with or sympathy for general or integrated courses. Certainly there was a general upsurge against the core as soon as it was put into operation.

As one of the teachers in the experimental sections of the science core, the writer believes that the course was, on the whole, successful in that its main objectives were achieved. Adverse circumstances were that lack of a text or syllabus made the course, as had been outlined, too long to cover. Too much lecturing had to be done, and minor changes in the prepared curriculum had to be made to relieve this difficulty. This caused adverse comment from some quarters that the course was not being taught as it was intended to be taught. This, however, was but a minor criticism. Not only the science core, but the whole program came under bombardment from the university faculty. The science core was not only attacked by those who had always preferred the two year program, but also by those who preferred none at all. The committee members who were formerly "neutral" now disavowed the course, claiming that they had merely done their best under compulsion.

An attempt was made to evaluate the course by a testing program[2] but the results were somewhat ambiguous, and they were used as data both to defend the course and to attack it as incompetent. Many attacks were made on *a priori* grounds. A course like this could not possibly be of any value; therefore, this course must be of no value. Pleas for further evaluation were unheeded. Advocates of the core were not only on the defensive, but received little opportunity to defend themselves or the course to the whole faculty.

Below, the more serious criticisms of the core are enumerated with whatever defense is possible. It will be noted that some of these criticisms are made from the standpoint that the course should have been a two years sequence (e.g. #1); others reflect the view that integrated courses are not a good thing (e.g. #13); while still others are valid objections from any viewpoint.

1. The course as planned caused the defeat of general education in science at the University of Pittsburgh at least temporarily. If the

[2] Fahey, George L. and Klaus, Dan J. Objective Evaluation of the Core Curriculum. Mimeographed Pamphlet, University Testing Service, University of Pittsburgh, 1956.

Physical Science-Biological Science two year sequence had been recommended the faculty would probably have accepted it.

REPLY:

Possibly so. It does seem unlikely that the faculty would have protested so against a plan which, whatever its faults, has been used in American colleges for over twenty years. It is unfortunate that the minority who believed in general education in science were never able to present a united front.

2. The course is too superficial.

REPLY:

Superficiality is a difficult charge to meet. The "standard" surveys have been criticized on the same ground, as have first year courses in individual departments. Any course in the university curriculum which does not attempt to cover everything known about its subject and then proceed into the unknown, may be and usually has been criticized on the grounds of superficiality. The only defense here is to reply that the course is just as superficial as it should be; no more and no less.

3. It contains so many diverse elements as to be confusing. Advocates of the one year plan criticized the lack of unity as a disadvantage of the two year plan. (E.g. see #9 of the objections to the two year plan preceding.) In a one year course still more discordant elements are lumped together with still greater confusion.

REPLY:

Not so. Integration is more easily achieved at the more "superficial" level where one cannot very well get into a methodological rut.

4. No text or combination of texts is available which covers precisely the ground of the course or does it in the manner desired.

REPLY:

True. Available texts were found to be inadequate.

5. There is a lack of good outside reading for this particular type of course, particularly in some fields. The normal texts are too thorough. Popularizations may be poor, inadequate, or, in some fields, lacking. Material with historical perspective usually requires a fair knowledge of the subject.

REPLY:

True, and this makes the student text—or lack of one—particularly important. In any case, it is not good to require freshmen to rely heav-

ily on library reading. They have not acquired habits of thorough study in the library; they feel more confident with material which they actually own and can reread. If there *were* a good text, the lack of good outside reading materials would be of minor importance.

6. The lack of text and student reading material causes the class to continue to fall behind schedule, rendering the course as planned impossible to teach.

REPLY:

True. Time should have been allotted for a student syllabus, at least, to have been prepared.

7. The time allotted (three meetings a week for three semester hours credit) was insufficient.

REPLY:

True. Four hours credit would have been better, including a two hour session once a week which could be devoted to a lab session if desired.

8. Mathematics was not well represented.

REPLY:

True, but it would be better represented if more economical means of teaching the course could be adopted.

9. Psychology, last on the program of the course, is likely to be slighted by an instructor if pressed for time.

REPLY:

Not necessarily. If he must slight something the instructor is just as likely to neglect whatever part of the course interests him least, or whatever he happens to personally consider least necessary for inclusion, rather than the last subject.

10. The instructor is forced to spend far more time in preparation than he can afford. In addition to the difficulties inherent in the presumed mastery of the entire field of natural science, much additional time must be devoted to organizing material for classroom presentation, which should be available as reading, and searching for suitable outside reading references.

REPLY:

True. Even without the ephemeral defects of no text, et cetera, the careful conducting of this course with a good testing program is a major task that should not be attempted along with much addi-

tional work. The idea that an instructor might teach two or three courses in his own department in addition to the core is untenable. No more than one such course should be attempted, and no course should be taught that takes a large amount of preparation. The instructor of a core course would do better to be taking other courses than giving them. No matter how much he knows in fields other than his own, he should be seeking to know more—to make his knowledge of them greater by personal contact and less by mere reading. It would probably be best if a teacher did no teaching outside the core. Some time for research might be provided, in which case the instructor should carry no more than one section per semester.

11. Regardless of other benefits that it may have, a course which demands so much of an instructor's time can never be economical. This alone is reason for abandoning it.

REPLY:

If the course is really the proper way to prepare the college graduate for informed citizenship and to introduce the prospective scientist to his field, then the expenditure of time will be worth while.

12. Staffing such a course is a hopeless task. Men with the necessary breadth of background cannot be found.

REPLY:

The staffing problem is probably not as great as generally imagined, and possibly no worse than that of staffing a two year course. There may be a surprising number of people on the staffs of most universities who have a background good enough to teach the course very well; but it may not be easy if equal departmental representation is enforced, rather than a search for the best personnel regardless of department.

In searching for qualified teachers of a one year science core, these points should be considered:

Men with a generalized background may be found in any science department, but they are far more likely to be found where a fairly generalized background is necessary, such as geology, astronomy and biology, rather than mathematics, chemistry and physics.

Men with a hobby interest in the history of science are good prospects.

The generalized scholar may not turn out to be a "research man" because his diverse interests may tend to prevent him from being sufficiently concerned with a narrow specialty.

13. If men could be found to teach the course they would not be of university calibre. They would probably be Masters of Science in

Education, prepared for the secondary or junior college level, whose knowledge of any one science is too shallow to permit any real first-hand idea of scientific research, or Ph.D.'s who have wandered so far afield as to have lost personal touch with research.

REPLY:

It is true that the M.S. in Science Education may not be well qualified to teach this type of course, regardless of his broad background. But anyone who can do a good job of teaching such a course is *per se* of university calibre.

14. If men of university calibre could be found, it would do them professional harm to teach this course.

REPLY:

Unfortunately, this seems to be true; at least within the observation of the writer. Universities want men who are specialists. Others do not get in. If an erstwhile specialist suddenly becomes known as "jack-of-all-trades," he is more likely to lose presitge than to gain it. The "pretention" of "knowing everything" is *prima facie* evidence of knowing very little indeed. A broad scientific scholarship has no market value.

15. This sort of course belongs in high schools. Integration is *not* desirable in college work. Like courses in "Remedial Reading," "Intermediate" Algebra, and Plane Geometry, this sort of hodge-podge debases college education. The student should finish general education in the secondary school. When he goes to college, it should be for the purpose of specialization. This is not to say that the colleges should be merely trade schools, but they should not be saddled with a fancied responsibility for teaching science to musicians or music to scientists. It is the business of the college to teach a prospective physicist physics, and the related fields necessary. He should not be *forced* to learn psychology. If he wishes to learn it he should be permitted to do so; if he doesn't, he should be granted the freedom of ignorance.

REPLY:

The above is an epitome of the position of those extreme adherents of the elective system who reject general education at the college level *in toto*. If it be granted that "terminal" education is the function of the secondary schools, the criticism is reasonable, if somewhat utopian. Certainly the trend in secondary science education seems to be for better upper-level students to take courses in physics and chemistry. General Science is for junior high school, and the poorer

upper-level students. In any case it seems likely that the integrated type of course as offered at the University of Pittsburgh would be beyond the general level of the senior high school.

Conclusion

At the time of this writing the fate of the Natural Science course at the University of Pittsburgh, as well as that of the whole core program, is in some doubt. Certainly it is a long way from being approved as a college requirement.

The one year integrated science course, as developed at the University of Pittsburgh, is regarded by the writer as theoretically the best answer to the problem of the freshman science requirement, but there are difficulties which must be overcome before it can become generally useful. The appearance of a suitable text would do most to make the course workable.

A Simple Home Made Ammeter

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To make an inexpensive direct current ammeter for the range from 0–5, 0–10, or 0–25 amperes, pass a wire lengthwise and horizontally through a cardboard box, put a pocket compass on top and turn the box until the wire is in line with the compass needle. When current flows in the wire, the needle will deflect and, as long as the deflection is small, (preferably not over 30 to 40 degrees) the current will be about one ampere for every ten degrees of deflection, provided the vertical distance from the wire to the needle is:

$1\frac{3}{4}$ inches in such southern states as Nevada, New Mexico, Oklahoma, Mississippi, Georgia
2 inches in Idaho, Colorado, Kansas, Tennessee, N. Carolina
$2\frac{1}{2}$ inches in Montana, Iowa, Indiana, Connecticut
3 inches in such northern states as Minnesota, Michigan, Maine

If the above distances are doubled, the current will be about two amperes for every ten degrees; if they are multiplied by five, about five amperes for every ten degrees.

In other states, consult a map and select a corresponding value for the distance from the wire to the compass needle.

Stimulating Interest in Science

Leon A. McDermott
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To stimulate interest in science and also to give high school students an idea of some of the possibilities science can offer as a career, Central Michigan College has, for the past four years, sponsored a science "open house."

This school serves a large and rather sparsely populated area in central and northern Michigan. In this area there are a number of small high schools which are not able to carry out large projects or hold science fairs. Teachers in these high schools are often required to teach a variety of subjects and cannot devote as much time to any one area as might be desired. To reach students from these high schools the idea of an "open house" started.

Although this idea is not new, the rather unusual thing about the program is the fact that at this college the idea originated in a group of chemistry and physics majors who belong to a departmental club known as the Alchemyst Club. A large percentage of these students are preparing to teach science in the high schools of the state.

The club members felt that they would like to invite the high school students from the adjacent area to see some of their demonstrations and projects. The first year the "open house" was held, approximately fifty people came from nearby high schools to see the science displays of the college students.

For the second year of the "open house" more high schools were invited to see the demonstrations, and a much larger group attended.

For the third annual event the Biology Club joined the Alchemyst Club in the project and prepared demonstrations of their own. This "open house" drew four hundred high school students, some coming from a distance of over one hundred miles. In addition, approximately one hundred college students took part as demonstrators, guides, and hosts for the group of young people who attended.

Included in the exhibit were demonstrations of dyeing, analytical methods, electronic devices, short-wave broadcasting, dust explosions, and corrosion action. There were also demonstrations in sound, light, heat, electricity, and atomic phenomena. Telescopic observations of the visible planets, the moon, and Arend-Roland comet were also made.

Biology students demonstrated dissection techniques, bird calls, botanical specimens, and laboratory techniques in slide making and blood testing.

During the current year the Geography and Geology Club in addition to the Biology Club asked to participate in the program. This

program drew approximately 450 high school students. The demonstrations were similar to those of the previous year with the addition of the geographical and geological characteristics of the immediate area.

The reaction of the high school teachers is very favorable, and they feel it worthwhile to bring students. The willingness of various organizations to participate in the program indicates the interest of the college students, who not only enjoy the work but also get a chance to learn techniques of demonstration which they feel are worthwhile. After each "open house" an evaluation of the program is made and each group contributes suggestions for the following year.

This appears to be one method of stimulating interest in science. Students from schools with limited opportunity have a glimpse of the many and varied aspects which science offers.

"NO HANDS" STEERING FEATURE OF EXPERIMENTAL AUTOMOBILE

A "no hands" steering control is just one feature of the new experimental automobile built and tested by General Motors.

The two-passenger, gas turbine powered car includes electronics, transistors and computers that guide the car automatically and control passenger comfort.

Primary features of the Firebird III, as it is called, are:

1. Wing-shaped Unicontrol handle that combines all steering, braking, accelerating and parking functions. The handle is mounted on a four-inch control stick located in the center of the car which is easily operated by either passenger.
2. Autoguide that provides electronic steering control.
3. Dual engine system that employs separate engines for car accessories and for driving the rear wheels.
4. A lighter, more compact gas turbine engine that uses 25% less fuel than earlier versions.
5. A single dial electronic temperature system that combines all conventional automotive heater and air conditioning controls.

BRAIN CHEMICAL LINKED TO VITAMIN DEFICIENCY

A simple chemical compound that is found only in the brain and spinal cord is now suspected to be involved in the epileptic-like seizures associated with vitamin B-6 deficiency.

The chemical is gamma aminobutyric acid (GABA). It was established in 1950 that GABA is formed from glutamic acid. This is a chemical long thought to have a special role in brain function.

Subsequent work has shown that a normal amount of GABA in the brain is dependent on the balance between its rate of formation and the rate at which it is used by nerve cells. A dietary deficiency of vitamin B-6, or a disturbance of the function of the vitamin in the body by chemicals, leads to a slower rate of formation of GABA and a consequent decreased amount in the brain.

So far, various attempts have failed to increase GABA levels in the brains of normal laboratory animals by treatment with drugs, or by injection or feeding of the chemical. GABA does not appear to enter the brain readily from the blood stream.

A Parabola Scheme

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If you want to draw a good parabola from its vertex to a given point, this three-guide scheme gives very satisfactory results. The three guides are (see Figure 1):

1. A circle at the vertex, center at *C*.
2. A tangent at the given point, *PN*.
3. A part-way point, *H*.

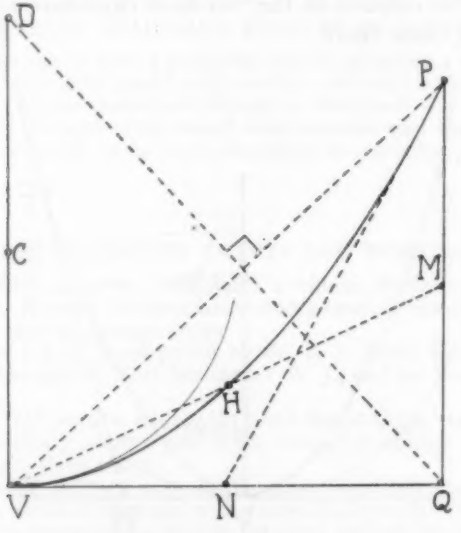

FIG. 1

For the construction of these guides, circle, tangent, and point, the directions are given below, followed by the necessary proofs later.

Let the vertex be called *V*. Two perpendicular directions through *V* will give the symmetry axis and the tangent at the vertex. The given point is called *P*.

1. Draw *PV*, and drop a perpendicular, *PQ* to the vertex-tangent. From *Q* draw a line perpendicular to *PV*, cutting the symmetry axis at *D*. Then *VD* is the diameter of the circle of curvature at the vertex: its mid-point, *C*, is the circle's center.

2. Bisect *VQ* at *N*, and draw *PN*. Then *PN* is the tangent to the parabola at *P*.

3. Bisect *PQ* at *M* and draw *VM*. Bisect *VM* at *H*. Then *H* is the part-way point on the parabola.

Both Figures 1 and 2 are used in the proofs, and we assume that the equation of the parabola is $2Ry=x^2$.

1. Take $(0, h)$ on the symmetry axis as the center of a circle which passes through the vertex. Its radius is h, and its equation is $x^2+(y-h)^2=h^2$, or $x^2+y^2=2hy$. For this to cut the parabola $2Ry=x^2$, we have $2Ry+y^2=2hy$; so the intersections have $y=0$ (the vertex) and the pair for which $y=2(h-R)$. For this pair $x=\pm 2\sqrt{R(h-R)}$. As h approaches the value $h=R$, the pair come closer and closer to the vertex. Allowing for the unavoidable width of a drawn line, we realize that with h nearly equal to R, the circle will seem to coincide with the parabola close to the vertex. The circle for which $h=R$ is recognized in the calculus as the "circle of curvature at the vertex," the best fitting circle there.

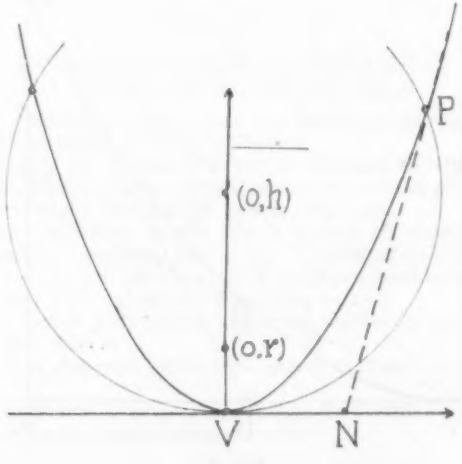

FIG. 2

To get the graphical construction for the case $h=R$, use the similar triangles PQV and QVD, in which, since P is to be on the parabola $2Ry=x^2$, we have $PQ=y$ and $QV=x$. From the proportion

$$\frac{PQ(=y)}{QV(=x)}=\frac{QV(=x)}{VD}$$

it follows that $(VD)y=x^2$, and so $VD=2R$.

2. To prove the tangency, let $x=a$ at P; then at P, $y=a^2/2R$, and the coordinates of N are $(a/2, 0)$. The equation of PN must be

$$\frac{y-0}{x-a/2}=\frac{a^2/2R-0}{a-a/2} \quad \text{or} \quad y=(2ax-a^2)/2R.$$

If this value of y on the line PN is subtracted from the corresponding (same x) value of y on the parabola, the remainder is

$$x^2/2R-(2ax-a^2)/2R=(x-a)^2/2R.$$

As this is never negative, the parabola, which grazes the line at P, never dips below it, but is tangent to it.

3. To show that H lies on the parabola $2Ry=x^2$, take P as $(a, a^2/2R)$. Then M is $(a, a^2/4R)$, and H is $(a/2, a^2/8R)$, which satisfies the equation $2Ry=x^2$, since $2Ry=a^2/4=(a/2)^2=x^2$ where (x, y) is the point H.

DEVELOP SPACE-AGE INSULATING MATERIAL

Difficult space-age insulating problems may be solved by a white fibrous material that combines light weight with excellent resistance to heat.

The product, fibrous potassium titanate, is composed of a compact mass of crystalline fibers. Because of the fibers' small diameter and high reflectance, the new insulating material blocks heat penetration by scattering incoming infrared rays.

NEW TELETYPEWRITER PRINTS 3,000 WORDS A MINUTE

A teletypewriter can print 3,000 words a minute, 20 times faster than most people can talk. It prints 50 times faster than a news service teletypewriter and 45 times faster than an average typist.

The device is a joint development by the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., and the Burroughs Corporation, Paoli, Pa.

Operating at 750 words a minute for Army Signal Corps needs, it will do the work of eight military printers now in use and get completed messages to their destinations eight times faster.

Instead of using ordinary keys, as do conventional teletypewriters, the new machine shoots letters at the paper with a series of electrode "guns." Each "gun" aims a beam at a corresponding spot on the paper and can fire any letter or number.

After the letters have been fired, each line of text passes rapidly over powdered ink and a heated roller and appears a split second later as clear, readable text. The device operates from standard code tape, or can be plugged into long-distance radio or telephone circuits.

The new machine is expected to be the basic unit in what the Army believes will be the fastest known military teletypewriter network.

ALUMINUM AUTOMOBILE BUMPERS FORESEEN

Aluminum's proven durability, ruggedness, light weight and resistance to salt spray make it a good choice for use in automobile bumpers, a spokesman for the Aluminum Company of America has told the American Society of Body Engineers. The increasing weight of cars, greater front axle load and smaller wheels are causing concern over tire loading, steering effort and engine horsepower requirements. It is believed that half the weight of contemporary bumpers, which vary from 50 to 150 pounds, could be eliminated through use of aluminum bumpers and bumper-grille combinations.

Science and the Curriculum*

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I shall develop two major points in this discussion: 1) *science is a great social force, and 2) science is a way of solving problems, of investigation as well as a way of living.* Likewise, I shall attempt to support a conclusion that the present problem confronting us is one of public and scientific illiteracy.

Science Is a Great Social Force

The literature pertaining to science education is replete with reference to our national scientific manpower shortage. But, prior to Sputnik and Muttnik (the earth satellites) the prognostications of science educators, and the everyday observations of college-university and business-industry groups were generally lost or ignored. Today, we are deluged with proposals for "catching up with the Russians," and many of these proposals are based on a naive notion that our schools, colleges, and universities can turn out more scientists, engineers, technicians, and dedicated science teachers *if we just put enough money into training programs.* There are proposals to subsidize science and mathematics teachers salaries, to offer any science or mathematics teacher "summer scholarships," to spend millions of dollars for scholarships to be granted to "gifted students," to re-write the textbooks in modern science terms, We are on the verge of "crash" programs in most states. What is wrong with us? Why are we so naive? Why are we so scientifically immature? Why do we continue to believe that more money will solve our problems?

The essential point is that *our schools, colleges, and universities cannot solve, alone, our present problems.* It is true that they may make a contribution, but we do not have a citizenry which has an understanding, a morality, a climate of opinion for the appreciation and utilization of science as the social method which it is, or the method of solving problems which science is. To a great extent, *our people are scientific illiterates.*

What we now need, and what we shall need for some time, is a scientifically literate citizenry—a citizenry which will operate in the mythical dimensions of the Italian street cleaner who sings high opera as he sweeps the street. Our street cleaners, our "masses" must sing, understand, and use science as a social force and method if we are to resolve our present dilemma. It is of the utmost importance

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that all of our people, and especially those who will not become research scientists, engineers, and technicians, possess such attitudes and understandings so that they will be able to collaborate and operate effectively with scientists to produce the kind of world which is now available to us. At present our people do not have this knowledge, conceptualization, or understanding—hence, they are scientific illiterates who cannot make intelligent decisions in the most important area of their life.

This means that of all of us, educators, industrialists, scientists, engineers, the "common man"—all of us must work for the most rapid development of a national consciousness in which science is correctly identified as *the most powerful social force of our time, and as a way of solving our most important and dramatic social and other problems*. This also states the role and function of science education in our schools, from the kindergarten through the college years. Only the senior college and university levels should deal with that specialization which is designed to produce specialists in science, engineering, and other related careers. This proposition can be supported more specifically, if we look at our country for the past sixty years.

Even by 1900 our country was a small nation—composed of small towns, only about 70 million people, isolated—in sixty years we have become a great world power, with responsibilities and international committments undreamed of in 1900. Further, today, our myths, stereotypes of behavior, traditions, habits, laws, and democratic ideals are still oriented towards a situation which does not now exist. This growth, in sixty years, has been so sudden, and the change brought about through developing science and technology have been so vast and pervasive, that our people are unsure, today, as to just what to do with all of the material wealth and power which they now possess. The tendency to rely upon stable social organization rooted in our constitution and law and to believe in leisurely social change has been replaced by the necessity for increasing and continuous re-adjustment of our social organization and institutional life—today we are confronted with increasing and conflicting social stress and strain, with conflict, at home and abroad.

In stable times words like freedom, democracy, and loyalty were understood, or at least their meanings could be "worked out" in "town meetings" or elsewhere. They were accepted and revered by most Americans. Today these words mean different things to Governor Faubus, President Eisenhower, The Klu Klux Klan, White Citizens Councils, Prime Minister Nehru, The Viet Namese, and our Soviet friends. Indeed, there are some in our country who say "Democracy, yes, but only for certain people, and to a certain ex-

tent." Others would change our governmental forms into a caricature of our dreams of liberty, justice, and equality for all.

The essential fact is that we are now in a mid-twentieth century crisis—our basic beliefs, principles, the "rules of the game" which have held our people together have beocme so vague and tenuous that they are no longer understood by our people as a whole. There is today less and less common purpose and objective. Our slogans have lost their common meaning, and we now tend to confuse the problem of defining democracy in the mid-twentieth century with communism. While communism is certainly an increasing international threat to the liberal democracies, we now tend to confuse the danger of spread of communism with our own crisis, and tend to concentrate on combating communism with our own crisis, and tend to concentrate on combating communism rather than strengthening and improving democracy. Clearly, our present task is to develop a mature informed literate citizenry which understands and is devoted to democracy, which will consecrate itself to the increase, cherishing, and extension of democratic values in tune with a society increasingly affected by the application of the inventions and discoveries of science. This can only occur in a group of people which correctly understands, appreciates, and are willing to use and accept the fact that science, and technology, have affected, will increasingly affect, and are intimately associated with our democratic value system.

Further, the important applications of scientific and technological inventions and discoveries to our society not only affect our democratic value system, but *science and technology have created vast opportunities for Human advancement which we are not now utilizing.* Today, for example, there is no scientific or technological reason for continued war and pestilence, or for many of our problems of human relations. Many of the problems which have historically plagued mankind could now be resolved *if we applied what we already know about science and technology.* Medical science, for instance, has increased our life expectancy, since 1900, by about 25 years—but this has not yet reflected in our notions about retirement, social security, or the role and function of old people in our world. For each scientific and technological advance has been accompanied by a "cultural lag" and we are now confronted with many problems which we have not solved.

We need only to look at the controlled release of atomic energy to identify this more definitively. The controlled release of atomic energy was not greatly different from other great scientific developments. It was achieved by a "rigorous common-sense," called scientific method, to a specific problem, development of "The Bomb." It resulted from an attack on fundamental problems of matter-energy

and in the manner in which energy and matter manifest themselves—this involved hundreds and thousands of men and women all over the world, over an extended period of time. When this fundamental knowledge was developed, conceptualized and reduced to principles and laws, the controlled release of atomic energy became a reality—and a chain of developments was set in motion which were technological, engineering, and social derivatives of the basic scientific achievement.

The bomb was only one of these derivatives. At the present time the bomb is intensified by global warfare, or its threat, since the search for controlled release of atomic energy was focused on the engineering problem of designing a weapon. The essential point here is that the BOMB was an engineering problem—as awesome as it is or was, it was an engineering gadget. It is comparable, to this extent, to the first internal-combustion engine in that it represents an *early* engineering application of basic scientific truths. In both instances, controlled release of atomic energy and the internal combustion engine, the bomb and the automobile were but one of a chain of technological applications in a set of scientific findings which have ever-widening implications for human activity.

Now we must face the basic question of why we are educating children and youth and older persons at all. For science and technology have developed so that they can no longer be considered as mere adjuncts to our general education—rather, they must take a place at the center of an educational scheme. This does not mean that the other disciplines are no longer important, what it means is that now science is important, perhaps more important. Further, we must face the fact that the old methods of teaching science, of recruiting people into science and related careers, are plainly incompetent to deal with our present needs. The trend of our schools and colleges to continue their rigid separation of science from society, to develop parrot-type learning, stifles intelligence and criticism, and produces individuals who know so little about the major factors affecting their lives that they are more at the mercy of demagogues and quacks than an illiterate people would be. These tendencies can no longer be dismissed as harmless. We have already seen how a people, such as the Germans and Japanese, who received the best education along traditional lines, can become more of a danger to themselves and others than any ignorant savage or barbarian nation ever was. The reform of education is therefore not a luxury, but a necessity if we are to safeguard our existing democracy and make possible its development into a more effective means of human cooperation.

If science is to take a central place in any new educational system it must be a science that relates far more closely than in the past to

the material and social aspects of everyday life—further, it must be linked throughout with the other parts of teaching and learning; with English, the social studies and humanities, the creative arts, and with the esthetic appreciation of the world in which we live. The methods of science teaching which have grown up in the past, and with which we now operate, were developed out of a need to provide training for specialists—doctors, engineers, chemists, geologists, and the like—they attempted to impart information and standard techniques. At best these methods provided competent specialists, at their worst they handed out information and knowledge that was so far out of relation to life as to be meaningless and impossible to remember.

We can, then, identify the following tendencies in science education philosophy, objectives, and pedagogy at the present time: 1) the *taxonomic*, based on mental discipline and faculty psychology, in which the emphasis is upon recognizing, classifying, and memorizing the individual facts with which the science is concerned; 2) the *static-descriptive*, based on behavioristic psychology, in which the objects of science are described in static and morpological terms, still with emphasis on memorization and mastery of "fundamental" content; 3) the *dynamic or analytical*, based on dynamic psychology in which the effort is to "fuse" or "blend" or "integrate" theories of chemistry, physics, and biology into "processes" or vice versa; and 4) the *holistic*, based on organismic, field theories, group dynamics and processes, in which a unitary approach to all phenomena is made, with the main aim to reveal interdependencies, interrelationships, and thereby evolve an ecological picture of all scientific phenomena. I shall devote the remainder of my discussion to the holistic approach, in terms of method and curriculum.

Conventional Programs in Science

Let us look briefly at the "older" or "conventional" programs in science. By "old" or "conventional" is meant those programs which have been referred to as based on taxonomic, descriptive, and dynamic approaches to the learning process. These three program approaches may be grouped together, and contrasted with the "newer" approaches based on holistic or organismic-field psychology, group dynamics, unitary field theory, and scientific-democratic methods of solving problems.

Whatever the science course which is taken, the conventional or older instructional procedure is much the same. Each student is expected to survey and study the textbook and learn (memorize) its content. The teacher's task is seen to be that of presenting "science" to the students, to clarify points of difficulty, to challenge the students thinking, to assist students in exploring the meanings of science

as they apply to their lives and to modern communities, and to do everything possible which is designed to ensure that the facts and subject-matter of science, as presented in the text is mastered.

Natural phenomena are presented by demonstrations, usually by the teacher, but often by individual students or student committees. These demonstrations generally employ standardized approaches, standard apparatus produced by commercial firms which specialize in studying the need for school science equipment and supplying materials that meet the need. The demonstrations serve the purpose of providing visual contact and impact of the textual account of science phenomena and to illustrate basic principles. Student projects are generally encouraged. Students are stimulated to make special studies through the use of various reference books and to construct and demonstrate models and apparatus in areas of special interest. Additional opportunities for following special interests are often provided through science clubs, fairs, junior academies of science, and other extracurricular activities.

Individual or group laboratory work is generally provided in physics and chemistry somewhat less commonly in biology, and occasionally in general-science courses, with little opportunity in the elementary school. A common procedure is to set aside two days a week for a double period of laboratory work, with laboratory manuals or workbooks provided, and the student required to complete a set of standard experiments during the course of the year. In Biology the laboratory is typically used for careful observation of parts of plants and animals, and, to a lesser extent, for occasional experiments on photosynthesis and digestants. Field trips are variously used including short trips to observe the implications of science being studied in their local communities and, in biology, to study living things.

Evaluation is chiefly by paper and pencil tests constructed by the teacher and by standardized examinations. Essay tests are sometimes used, but evaluation is overwhelmingly by formal objective tests in which the student is expected to check the correct answer to a series of true-false, multiple-response matching, or similar objective-style test items. Grades are often raised or lowered on the basis of projects done, accuracy in laboratory work, effectiveness and accuracy in classroom recitation, and the apparent degree to which the student is working up to his capacity.

The most notable feature of the older programs is that the textbook forms the program. Modern textbooks are generally excellent textbooks, they provoke thought, present interesting problems, are lucidly written, and offer many examples of how science is related to life. Good teachers in the older programs added to the textual account from their own experiences, drew on the students' experiences, and

developed interesting and challenging courses. But the easiest way to determine just what is done, what is covered, and how much time is spent on any one topic in the conventional program is to examine the text being used. The textbook determines the program, and to a great extent, how it is carried out.

Criticism of the Older Programs

The defects of the older programs are most clearly identifiable when we look at their contribution to development of critical thinking scientific attitudes and abilities, problem-solving skills, and understanding of the social role and function of science.

There is little evidence that the older programs developed critical thinking and problem solving skills and abilities. While it is difficult to define scientific method or problem solving skills and abilities, we do know many of its ingredients. It is mistaken however, to assume that accounts of the great scientists, discussions of scientific method, and typical recitation and laboratory practices result in increased critical thinking on the part of the student. The stereotyped conception of scientific procedures of inquiry have been notably ineffective in producing critical and incisive abilities, and have failed to give the majority of our youth increased power to tackle the problems of daily living.

If we are honest, we must admit that the usual science teacher has given little sustained thought to how to develop problem solving skills and abilities, critical thinking abilities, or even made the distinction between a critical minded person and a sloppy thinker. The teacher has vaguely assumed that the textbook, and the laboratory exercises will get this job done.

The conventional science teacher feels honor-bound to cover the material of the text he is using. He feels guilty if the end of the semester or year finds several units yet uncovered. Although he realizes that, at best, he can only cover a small portion of the science he is teaching. He nonetheless struggles to sweep over at least a majority of the content found in the text he employs. This has typically resulted in an emphasis on the acquisition of facts rather than an emphasis on increasing the power of students to obtain facts and use them intelligently in making decisions. Attempts to cover the many facts of science have allowed students little time for development of real understanding of exploration of variant and conflicting viewpoints. The typical teacher does not allow for much doubt or skepticism, and yet doubt and skepticism are essential ingredients of the scientific attitude and critical thinking, and should be nurtured and directed, not ignored or stamped out.

Secondly, conventional teachers often deal with facts to the virtual

exclusion of real problems. They seldom recapitulate the storms, controversies, and wrong answers that were historically the experience grounds for the development of the scientific abilities of many men of science. The problems in conventional science teaching are textbook problems, neatly identified, strait-jacketed, and baldly answered under a single-tract forced draft of steps and progressions. These are as useless for development of critical procedures of thinking as they are atypical of real-life problems.

Thirdly, the very nature of subject matter, a body of organized and tested knowledge, admits of little or no argument—as it is commonly taught. The science teacher has conventionally dealt exclusively with the body of factual knowledge, called science, and emphasized its memorization and retention, rather than analysis. E always equals I^R, it is a principle to be learned as if it were fact. Actually, it requires no reasoning to be learned as presently taught. It adds little to development of scientific method and attitude, and in addition, teaching principles as if they were facts can hardly result in real understandings leading to applications in daily life.

Frankly, the majority of learning experiences of the teachers in conventional programs are memoriter and verbalistic. They do not habituate the youth to critical attack on problems or to inductive reasoning, or guide students toward higher synthesis of critical abilities than they had before they came to class.

Nor can the laboratories be said to emphasize development of scientific attitudes or critical abilities. A student is sent to the laboratory to find, with inadequate instruments and equipment, answers that he already knows in advance or that he knows are in the teachers notebook. The student does not determine the coefficient of expansion of a piece of metal by recourse to nature, on the contrary he goes to the laboratory to see how closely he can get nature to conform to the "right" answer that appears in the answer book, or the teachers notes. The answer, for the student, is an arbitrary authoritarian one, and thus laboratories become places where students often engage in the dubious game of checking as closely against the arbitrary and unchallenged authority of the textbook, the teacher, and SCIENCE.

Further, sooner or later some chemistry teachers will mix chemicals so that students cannot get results the laboratory manuals indicate they should get. The substitution of chemicals by the teacher makes it impossible to get the results the manual says should be obtained. Yet the majority of the class will report the result that the manual has led them to expect. This intellectual dishonesty however is not a reflection on the personal integrity of the teacher, because the students inadequacies have not permitted him to achieve the "right" answer. The science teacher has actually taught this intellectual dishonesty

and disregard for observable facts as if they were one of the chief objectives of his teaching, since the teacher has emphasized "right" answers to be those in the text, the manual, or the teachers notes.

Thus, conventional science teaching is authoritarian, and therefore undemocratic, or even anti-democratic to this extent. The teacher does not tolerate deviation from the "facts" of science, the laboratories are not really laboratories at all, the experiments are not experiments, but visual education devices for visualizing the phenomena and gaining facility in manipulation of certain materials and apparatus. The objection here is not to using laboratories for visual education purposes, but in the attempt to fool ourselves into believing that what goes on in the laboratory contributes to scientific attitudes and critical thinking, and problem-solving skills and abilities.

Basic Elements of the Newer Programs

In the newer programs students assume a high degree of responsi bility for planning the areas of content, organization, and procedures of the course. In more conventional programs the teachers and textbooks largely determine these things. In the newer programs students are close to the active center of the learning process than they are in conventional programs. The teacher counsels and stimulates the students and serves as a resource of guidance and technical information when other resources fail. Direct teaching is done, but is less prominent than in conventional programs.

These are not accidential differences, but are planned to achieve the most fundamental objective of the newer programs—developing in each student self-direction, purposiveness, and power of independent attack on problems. These scientific abilities are spoken of as critical abilities, and the attempt is to provide experiences that will teach the student to handle his own problems without a teacher or textbook beside him, with the hope of making the teacher and formal education increasingly dispensible.

1. The ability to locate and define problems in the matrix of confused patterns in which they are commonly found in real-life situations
2. The ability to outline problems so that they may be analyzed and attacked by a logical series of steps
3. The ability to secure relevant information from appropriate references and to distinguish between data that are valid and those that are invalid. This includes recognition of the basis of authority and the meaning of authority in science
4. An increasingly explicit understanding of science as a method of formal inquiry with recognition of both its potential usefulness and its limitations when applied to socio-economic affairs
5. Recognition of the validity of the group as well as individual attack on problems and recognition of the common requirements of freedom for the advance of both science and democracy
6. Increased ability in the communication arts—reading with preception and understanding, critical listening, effective speaking and writing, effective participation in group discussion, and critical thinking

7. A tendency to act in accordance with available facts and within the value systems of both democracy and science.

Applied to newer programs, these holistic modern conceptions applied to these objects of the role and function of the teacher mean:

1. That neat problems pulled out of context of real-life involvement will not suffice for effective education—only in textbooks are problems neatly defined. In life, real issues and problems are submerged in a matrix of irrelevancies and false issues. The primary responsibility of the new teacher is to help young people look more critically at science situations as they are found in life and help them locate and define the science problems that are found in such situations. The teacher would avoid presenting clear-cut problems to the class, rather he would help students become aware of meaningful problem situations in science and help them identify and clarify the concrete problems involved in these situations. The problem situations chosen depend on the maturity, interest, and need of the group, and typically emerge from the group.
2. Objective two suggests group planning and deliberation, with the entire group commonly planning procedures to be followed in the attack on a problem, and then delegating to small groups and individual individuals responsibilities for investigation. The individual might and probably will have interests not shared with the group. That student would present his interest or state his problem to the entire group (Or committees of the group) criticize its structure, and assist the individual student in refining it to the point that he clearly understands what things must be done in order to secure the data needed to answer the problem-question or resolve the issue of his concern.
3. Objective three deals with the role of the textbook in the newer science program. The use of a single text without reference to other sources inhibits development of this objective. Moreover, the teachers of the newer programs insist that the student who goes through a conventional program is unable to use newspapers, periodicals, reference books, and technical bulletins critically when he needs information. While some teachers in the newer program believe that textbooks are by nature bad, most prefer using multiple textbooks, or a single textbook supported by a rich resource of library reference material. The textbook or books serve then as a reference point for learning expeditions into a wide variety of experiences, but does not dictate coverage of the course. The wide use of reference material is desirable because of the range of reading abilities, and variation in speed of coverage. Further, wide reference use takes into account the wide range of reading interest and intelligence. While many of the newer textbooks are far better organized than the traditional ones, it must be emphasized that the most gifted and insightful author cannot know and meet the various local situations the teacher faces, nor provide for organization of content that will meet particular psychological requirements of a particular student in a particular class. Authors of many of the new texts therefore provide many suggested activities, reading materials, and sources that encourage the student and teacher to go beyond the text into the life of the community and into a wide variety of reference material. Thus, the new tests attempt to wean the student away from preoccupation with single text.
4. Objective 4 suggests that students recognize science as one of the several historical and contemporary means of formal inquiry. The students real understanding of science as a method will depend on the adequacy with which the other six objectives are realized—it will depend on use and habituation in that method. These objectives are aspects of the scientific method, and assume that it is valuable for students to take stock of procedures of investigation and distinguish clearly between scientific inquiries, and those based on intuition, pure reason, revealed truth, philosophical and historical methods, artistic analysis and synthesis, superstition, and the like. Thus,

the newer programs stress science in its interaction with the many social forces operating at a particular time and place.

Furthermore, the teachers of the newer programs recognize and teach students to clearly see, that scientific method varies in its application;

Furthermore, the teachers of the newer programs recognize and teach students to clearly see, that scientific method varies in its application; methods employed in a physics or chemistry laboratory where controlled variables make controlled investigation possible, may not be used in other situations where uncontrolled variables make controlled investigation possible.

On the other hand, the newer programs do not make the distinctions between the natural and social sciences which conventional programs often do, and, where possible, in helping young people understand natural phenomena, the newer programs include social phenomena which are amendable to scientific attack.

5. Objective 5 emphasizes cooperativeness. Conventional programs emphasize competitiveness. The goal of the newer programs is optimum development of each individual, with shared and group responsibilities believed to be the best sort of habituation for the democratic process and of significant help in increasing the emotional security and maturity of the student. Further, it is believed that modern science is an exemplification of democracy at work in modern times. Each scientist has stood on the shoulders of those who worked before him, and no scientist really works alone, although working individually, he reports his assumptions and procedural details, conclusions, so that others may determine the validity of the conclusions reached, since conclusions in science are not acceptable until there has been considerable group verification.

   Thus, in the newer programs the student experiences the validity of this group attack, and exposes his assumptions, facts, experimental procedures to the critical view of the group just as the scientist does. The result are sounder answers, and common adhering in formation of assumptions, collection of data, formation of tenable conclusions and generalizations. The individual student gains respect for group processes and learns that exposition of facts before others improves his performance.

   The most common outlet for information, understanding, and attitudes is through verbal communication.

6. Objective 6 posits that there is no area of human experience that is not directly or indirectly affected by science. Therefore, students in the newer programs are assisted towards development of critical understanding of the written and spoken work, and aided in their ability to communicate beliefs and views with cogency. A considerable time is spent, in the newer programs in group discussion, panel discussion, library research, individual presentation, informal group analysis, with an intimate relation between language and thought revealed. Practice in expression is also practice in clear thinking, and science students are provided considerable opportunity to improve in such use through supervised learning experiences.

7. Objective 7 is designed to help students bridge the gap between knowledge and understanding and action. Objective 7 states the desirability of providing outlets for knowledge and attitudes so that young people will experience the satisfaction of successful action and become socially desirable and individually more satisfying. Such experiences enable the student to develop to the fullest their personal and group potentialities for intellectual maturity and desirable democratic activity.

   Hence, the newer programs provide opportunities for discovering many avenues of action such as writing letters to the local editors, addressing clubs, modifying human relations, undertaking surveys of health, housing, recreational potentialities, wiser purchasing techniques, sounder use of equipment and facilities, and the like. Teachers in the newer programs do

not leave these forms of action to chance. They help young people gain increased skill in these and other forms of desirable social action.

Thus there is no set body of content reflecting the newer programs of science. While this may be unfortunate, from one point of view, it is still impossible to generically describe the content of the newer science programs. The content varies from semester to semester in its details, since teachers give priority to the competence objectives described above. These competence objectives prohibit a teacher-dictated static content and encourage flexibility and group consensus on appropriate content.

However, this does not mean that the newer programs are without shape and direction. Or, that they represent easy or superficial treatment of science content. Although the details of content cannot be stated, each student in the newer courses delves more deeper into several aspects of the science being studied than he would have in the older programs. Coverage of content is not so broad in the newer programs as in the older ones, although the gifted individual student goes even more deeply. But the content emphasis depth rather than extensiveness, each student is expected to know well what he knows; mastery of subject matter, is not the only content goal.

In addition, the newer programs are designed specifically for the purposes of general education. All students are expected to know certain principles and concepts of importance in personal and social affairs. The first criterion for selection is the problems and needs of students themselves, and those basic needs possessed in common become the common or general education base for the learning experiences. The teacher in the newer program conceives his responsibility to contribute his expertness in helping students meet significant persistent personal needs.

Societal needs are another criterior for selection of content in the newer science courses. This includes student understanding that scientific and technological abilities now may enable man to provide more adequately for human wants in production, health, conservation, and similar areas. The goal is to provide understanding that it is now technically possible that our people may have a firmer base in fact to judge the many proposals put to the American people to narrow these gaps.

The newer programs are also concerned with many areas of social concern; with modern mass production, the interrelations of peoples and nations in the modern world, antiscientific conceptions about human nature and inheritance, naive undemocratic, unscientific notions about control and use of atomic energy, and its development for the benefit of mankind; and the larger questions of war and peace.

Finally, the value system of democracy forms the base for selection of content in the newer programs of science. These are the values of freedom loving people which have emerged from the struggles of mankind towards dignity, freedom, liberty, equality, fraternity, and justice. Science, like democracy, requires freedom of the mind for its survival and advance.

CHEMILUMINESCENT MIXTURE

The Shawe Memorial High School Science Club, Madison, Indiana, has prepared a chemiluminescent mixture that they call "Chemi-Lite (Blue)." The mixture can be used in various science classes. In chemistry it can be used to demonstrate chemical reaction: chemical reaction with the production of light energy. It can complement the usual exothermic reaction of iron and sulfur.

A teacher may obtain 15 grams of the mixture by requesting "Chemi-Lite (Blue)" on school letterhead and enclosing fifteen cents (15¢) in coin. The request should be addressed to:

Theodore A. Winkel
607 N. East Street
Madison, Indiana

UNIVERSE AGE NOW JIBES WITH RADIOACTIVE DATING

The universe is from seven to 13 billion years old, a cosmic age that jibes for the first time with that from radioactive dating.

The latest estimates of the universe's birth time result from studies made with the giant 200-inch Hale telescope atop Mt. Palomar, Calif. The world's biggest "eye" this year begins its second decade helping man understand the vast complexities of space.

Within the next five years, Palomar astronomers hope to complete the colossal task of finding out the size of the observable universe and how much matter it contains. They will also try to learn whether the expanding universe shows signs of slowing down at the limits of observable space.

ASTRONOMY FROM SATELLITES FORESEEN WITHIN TWO YEARS

Study in the universe, and particularly the sun, from earth-circling artificial satellites to obtain an unobstructed view 24 hours a day will be possible within a year or two.

Dr. Leo Goldberg, director of the University of Michigan Observatory, predicted that astronomy from satellites is just around the corner.

A payload of only 300 pounds, believed "certainly feasible" within two years, would be sufficient for instruments needed by the solar satellite. Plans for such a satellite, which would orbit at a height of 400 miles in a path from pole to pole to obtain continual sunshine, have been drawn by a St. Louis aircraft manufacturer.

The biggest problem of present-day solar observatinos is that much of the sun's radiation, including the ultraviolet, is absorbed by the earth's atmosphere. The visible light reaching the earth's surface does not tell the whole story of the sun's voluminous outpourings.

Paper Chromatography for the Secondary Schools

II. The Analysis of Alloys and Minerals

John G. Surak and Sr. Mary Lucilda Sewald,* OSF

Marquette University, Milwaukee 3, Wisconsin

Circular or radial paper chromatography enables the instructor to place the application of paper chromatography as an analytical tool within the capabilities of the elementary chemistry student. It is a rapid and efficient method of analysis. Identification of the unknowns can be easily effected by use of the technique of mixed chromatograms which permits the identification of the unknown by reference to the known run on the same chromatogram.

After one has familiarized himself with this technique by analyzing and identifying the common cations individually and in mixtures, (see Part I), the experimenter will be ready to analyze some of the simpler alloys and minerals containing these cations. These alloys and minerals may be purchased from chemical supply houses. However, we have found that our local industries are very cooperative in giving us samples (with their analyses) of the alloys used in the manufacture of their products. These samples become a challenge and an incentive to the student as he visualizes himself as being the "chemist for that company" and that "he is conducting an analysis of the materials going into the manufacture of their product." Some of the materials which we obtained were: Nickel-copper alloys (such as: nickel coinage, monel metal, and German silver); bronzes; duralumin; type metal; arsenical lead; and stainless steel; among the minerals and ores available were: feldspar; bornite, chalcopyrite, malachite, cuprite, hematite, magnetite, and spiegeleisen.

In this experiment, alloys and minerals should be selected whose constituents are within a definite qualitative solvent system. However, as a challenge to the more able students, some alloys whose constituents are in different qualitative groups may also be used. In these cases redevelopment and/or multiple development techniques with different solvent systems will have to be used.

The techniques of redevelopment with a single solvent and multiple development with different solvents are effective in causing diffused areas to concentrate into sharper bands, and in many instances improve the resolution. It is necessary to thoroughly dry the filter disc between each redevelopment or multiple development. Fresh solvent solution should always be used when rerunning the chromatograms. The solvent is permitted to run *only* to the *original* solvent front each time. Redevelopment and multiple development is

* Present address: St. Mary's Academy, Milwaukee, Wisconsin.

done *before* the paper is treated with the chromogenic reagent which is used to reveal the resolved cations. Trailing, comet formation, and diffused areas of the chromatographed cations can be minimized by varying: the concentratioon of the solutions being analyzed; the pH, and the water-to-solvent ratio.

A Typical Experiment

Analysis of copper-nickel alloys (such as: coinage, German silver and monel metal).

Procedure

(1) Dissolve a small quantity of the alloy in a suitable mineral acid (aqua regia) and dilute with distilled water to give a solution that contains approximately 5% (*w*/*v*) of the alloys. The exact dilution needed, that is , one which will give an acceptable chromatogram, can be ascertained by experimentation.

(2) Prepare the filter discs as described in "Paper Chromatography for the Secondary Schools: I."

(3) Place 0.01 ml. droplets of the solutions of individual cations of known mixtures to be used as comparative standards and of the solutions of the alloys to be analyzed on different positions on the prepared filter paper disc (see Part I).

(4) Permit the spots to dry and develop the chromatogram.

(5) After development, thoroughly air dry the filter disc to remove residual solvent.

(6) By means of the "wick feed-method" used in development of the chromatograms, reveal the positions of the resolved cations with suitable chromogenic reagents.

(7) Determine the Rfc values, identify the unknowns by comparing the positions and colors of the cations contained in the "unknown" mixture with those of the "known" cations.

(8) If areas are diffused, indistinct, or smeared, repeat the experiment. Change the concentration of the unknown sample and use either the redevelopment or multiple development technique for developing the chromatogram.

Discussion

The same technique and procedure is used in resolving and identifying the constituents of minerals.

Table 1 lists the solvent systems used in separating the common cations in the conventional qualitative scheme of analysis. (Refer to Part I.) However, other solvent systems listed in literature should also be tried by the student.

Table 3 presents in a tabular form the alloys analyzed, the solvent system used, time required for a single development, identifying agent used to reveal the constituents present, and the color obtained.

Table 2 presents the same information on some common minerals and ores.

This technique may be modified and adapted to analyze other "products" of the community.

TABLE 1

SOLVENT SYSTEMS

Group I	85% *n*-butyl alcohol 15% H_2O Sufficient glacial acetic acid to make a pH of 2.5–3.5
Group II	40% tertiary butyl alcohol 40% acetone 11% water 4.5% nitric acid (6 *N*) 4.5% acetyl acetone
Group II B	45% tertiary butyl alcohol 45% chloroform 8% hydrochloric acid (8 *N*) 2% acetyl acetone
Group III A	40% tertiary butyl alcohol 40% acetone 20% 3 *N* hydrochloric acid
Group III B	90% acetone 10% HCl (6 *N*)

TABLE 2

ANALYSIS OF MINERALS

Mineral	Solvent System	Time (hrs.)	Chromogenic Reagent	Constituents	Color
Feldspar	Group III-A	6–7	Alizarin	Aluminum	violet
Bornite	Group II-B	1½	Dimethylglyoxime	Copper Iron	green brown
Chalcopyrite	Group II-B	1½	Dimethylglyoxime	Copper Iron	green brown
Malachite	Group II-B	1½	Dimethylglyoxime	Copper Iron	green brown
Cuprite	Group II-B	1½	Dimethylglyoxime	Copper Iron	green brown

TABLE 3

Alloy	Solvent System	Time (hrs.)	Chromogenic Reagent	Constituents	Color
Coinage	Group II	1¼	Dimethyl-glyoxime	Nickel Copper	d. pink brown
German Silver	Group II	1¼	Dimethyl-glyoxime	Nickel Copper	d. pink brown
Monel Metal	Group II	1¼	Dimethyl-glyoxime	Nickel Copper	d. pink brown
Type Metal	Group II-B	5	Hydrogen Sulfide	Tin Lead Antimony	tan brown orange
Solder	Group II-B	5	Hydrogen Sulfide	Tin Lead	tan brown
Arsenical Lead	Group II-B	4	Hydrogen Sulfide	Tin Lead Arsenic	tan brown yellow
Duralumin	Group II Group III-A (Multiple-Development) Technique	2½ 2½	Dimethyl-glyoxime Hydrogen Sulfide Alizarin	Iron Copper Aluminum	brown d. brown red
Manganese Bronze	Group III-B Group III-A (Multiple-Development) Technique	1 1½	Dimethyl-glyoxime Alizarin	Copper Iron Aluminum Zinc	green brown red violet
Cadmium Solder	Group II-B Group II (Multiple-Development) Technique	1 1½	Hydrogen Sulfide	Tin Cadmium	tan yellow

A QUERY

Is the drying action of a towel due wholly to capillary effects in the minute tubes and pores of the towel, these tubes and pores being formed by the interlacing fibres of the towel which form extremely narrow conical capillary tubes? preceding this capillary action there may be, of course, a mass sweeping action of the water off the wiped article, but ultimately capillary action (and other surface effects, e.g., adsorption) seem to be responsible for the drying of the article, and this is an action we rarely try to explain.

JOHN SATTERLY
University of Toronto
Toronto, Canada

A QUERY OF POSITION

Why so very often when one is dressing, does one find that on the floor the right-foot shoe is on the left-hand side of the left-foot shoe? I am not left-handed and I wonder whether this effect is just peculiar to me. Have others noticed the same?

JOHN SATTERLY

Happy Valentine Day to You

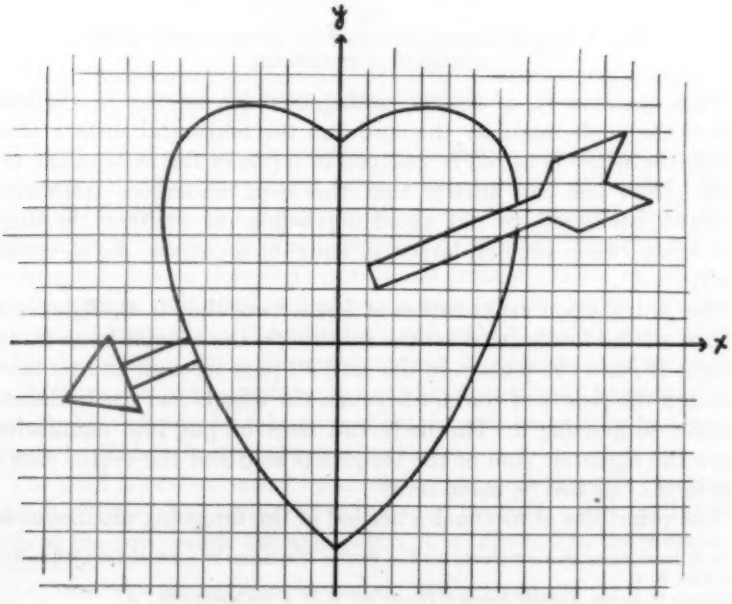
Norma Sleight

New Trier Township High School, Winnetka, Illinois

Ralph Shuey, a junior student in an advanced placement section of mathematics at New Trier High School, brought in this list of statements to be duplicated for his class. It was his valentine to all of us. Perhaps it was retaliation for similar tasks given to him. Anyway, we pass on to you the results of Ralph's labors.

Graph carefully on the same set of axes:

1. $13x^2+7y^2+6xy\sqrt{3}=400$, $x<0$
2. $13x^2+7y^2-6xy\sqrt{3}=400$, $x>0$, $y<4.1$, $y>5$
3. $5y-2x=12.6$, $7.4>x>1.05$ and $-5.6>x>-8.1$
4. $5y-2x=7.4$, $7.75>x>1.4$ and $-5.3>x>-7.8$
5. $2y+5x=11$, $2.9>y>2$
6. $2y+5x=-42$, $.25>y>-2.5$
7. $y-1.3x=11.35$, $-10.3<x<-8.5$
8. $2y+.3x=-7.2$, $-10.3<x<-7.4$
9. $y-2.3x=-11.5$, $6.8>y>5.5$
10. $y+.4x=7.8$, $9>x>7.75$
11. $y-2.3x=-17$, $8>y>6$
12. $y+.4x=10$, $11.75>x>10$
13. $5y-2x=3$, $11.75>x>9$
14. $5y-2x=18.1$, $10.9>x>8$



The Spool Problem

(Ninth in a Series)

Harald C. Jensen

Lake Forest College, Lake Forest, Illinois

A question often posed in physics textbooks[1,2] concerns a spool like the one shown in the figures. The spool consists of an axle of radius R_1 connecting two wheels of radius R_2 with $R_1 \cong R_2/2$. The query is this: If a cord wound around R_1 is pulled, in what direction does the spool roll?

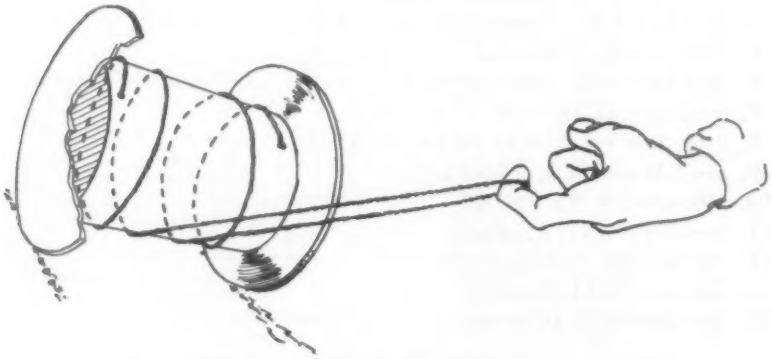


FIG. 1. View of large spool useful for demonstration of the conditions of equilibrium.

This question is, of course, ambiguous. No answer is available unless the angle made by the cord and the horizontal surface along which the wheel is to roll is specified in terms of the ratio of the two radii. Then one can answer that the spool undergoes translation forward, backward, or not at all depending on whether the angle θ in figure two is smaller, larger, or equal to arc cosine R_1/R_2 respectively.

One notes, upon examination of figure two, that if $R_1/R_2 = \cos\theta$ then all the forces (that is: the friction fr, the normal force N, the weight W, and the tension in the cord P) pass through an axis taken through the points of contact between the wheels and the horizontal surface supporting it. The body can then be put into equilibrium since the algebraic sum of the torques is zero and the vector sum of the forces can also be made zero.

The principles of mechanics needed in the foregoing discussion are

[1] N. H. Frank, *Introduction to Mechanics and Heat*, Problem 43 in chapter 10, p. 190. McGraw-Hill Book Co., New York, N. Y.

[2] Gordon M. Martin, *American Journal of Physics*, Vol. 26, #3, p. 194, March 1958.

fundamental and are demonstrated forcibly by this device. It seems very worthwhile then, to have a large spool available for both demonstration and exhibit use.

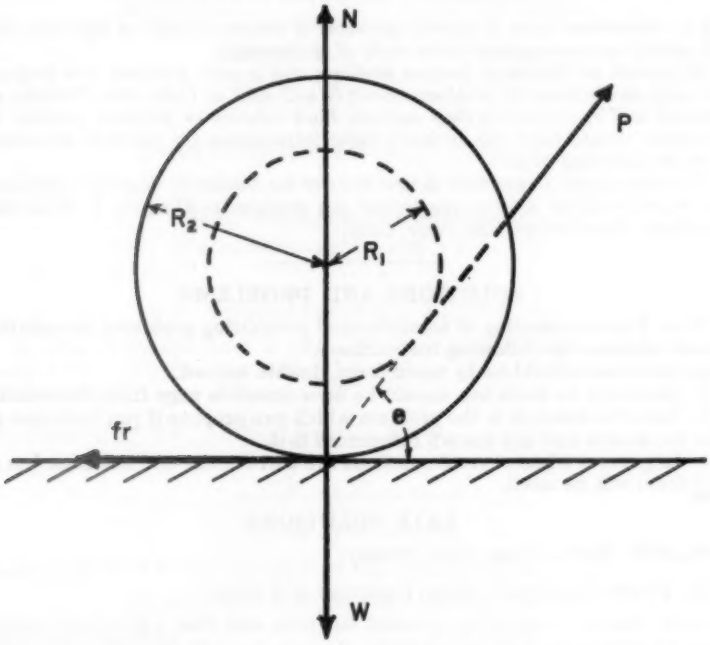


FIG. 2. Drawing showing forces acting on the spool when supported by a horizontal surface.

A large spool can be constructed quite simply from very inexpensive materials. Bakelite tubing, such as that used for coil forms, three inches in diameter and six inches long or a tin can with both ends removed can be used very satisfactorily as an axle. The two wheels, about six inches in diameter, can be cut from masonite or plywood by the method described in a previous paper of this series.[3] A simple method of connecting the wheels to the axle is as follows. Smaller disks of masonite, cut in the same manner, of a diameter equal to the *inside* diameter of the axle are fastened concentrically to each of the wheels. This allows the tubing used for the axle to be attached to the wheels by sliding it over the smaller disks.

The cord is best attached by threading its ends through two small holes, one hole being drilled at each end of the axle, and knotting the ends of the cord inside the axle before it is fastened to the wheels.

[3] H. C. Jensen, SCHOOL SCIENCE AND MATHEMATICS, Vol. LVIII, p. 712, Dec. 1958.

Problem Department

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2626, 2632. *Bjarne Skaug, Oslo, Norway.*

2635. *Proposed by Cecil B. Read, University of Wichita.*

Given that a, b, and c, are rational numbers, and that $\sqrt{p}/\sqrt{q}$ is irrational, prove that if $a+b\sqrt{p}+c\sqrt{q}$ vanishes, then $a=b=c=0$ (p and q are rational while $\sqrt{p}$ and $\sqrt{q}$ are irrational).

Solution by C. W. Trigg, Los Angeles City College

Since $\sqrt{p}/\sqrt{q}$ is irrational, $\sqrt{p}\neq\sqrt{q}$ and neither vanishes. Hence if $a+b\sqrt{p}+c\sqrt{q}=0$, then $a=0$ and $b\sqrt{p}+c\sqrt{q}=0$. It follows that $b(\sqrt{p}/\sqrt{q})+c=0$, whereupon $c=0$, $b(\sqrt{p}/\sqrt{q})=0$, and $b=0$. Therefore, $a=b=c=0$.

A solution was also offered by the proposer.

2636. *Proposed by Brother Norbert, Chicago, Ill.*

Prove that the ratio of the area of the triangle formed by the tangental points of the inscribed circle as vertices, and the original triangle is equal to twice the product of the sines of the half-angles of the original triangle.

Solution by W. E. Hoff, Ferguson High, Ferguson, Missouri

The triangle ABC has the points of tangency of the inscribed circle labeled D, E, and F. Thus the triangles ADE, BEF and CFD are isosceles triangles. These triangles and the Law of Sines gives:

$$\text{Sin } \tfrac{1}{2}A = DE/2AE; \qquad \text{Sin } \tfrac{1}{2}B = EF/2BF \text{ and } \text{Sin } \tfrac{1}{2}C = DF/2CD$$

Let Q represent twice the product of the sines of the half angles. Then

$$Q = 2 \text{ Sin } \tfrac{1}{2}A \text{ Sin } \tfrac{1}{2}B \text{ Sin } \tfrac{1}{2}C$$
$$= 2(DE/2AE)(EF/2BF)(FD/2CD)$$

If s is the semiperimeter of ABC, it is the sum of AE, BF and CD.
Then

$$s=AE+BF+$$
$$AE=s-BF-CD$$
$$=s-BC$$
$$BF=s-AC$$
$$CD=s-AB$$

So:

$$Q=(DE)(EF)(FD)\div 4(s-BC)(s-AC)(s-AL$$

but

r = the radius of the inscribed circle and
$$r^2=(s-BC)(s-AC)(s-AB)\div s$$

thus

$$Q=(DE)(EF)(FD)\div 4r(rs)$$

But the area of triangle DEF *is* $(DE)(EF)(FD)$ divided by $4r$ and the area of triangle ABC *is* (rs), therefore, 2 Sin $\frac{1}{2}A$ Sin $\frac{1}{2}B$ Sin $\frac{1}{2}C$ equals the area of triangle DEF divided by the area of triangle ABC.

2637. *Proposed by J. W. Lindsey, Amarillo, Texas.*

Solve for x

$$x^4+4x^3+7x^2+20x+10=0.$$

Solution by the proposer

Adding $(mx+b)^2$ to both members of this equation gives

$$x^4+4x^3+(m^2+7)x^2+(2mb+20)x+b^2+10=(mx+b)^2.$$

Assume the identity

$$x^4+4x^3+(m^2+7)x^2+(2mb+20)x+b^2+10=(x^2+2x+q)^2.$$

Equating coefficients, we obtain

$$m^2+7=2q+4,$$
$$mb+10=2q,$$
$$b^2+10=q^2.$$

Eliminating m and b from these three relations, we have the cubic

$$q^3-7/2q^2+10q-35=0.$$

This cubic has a root $q=7/2$. The corresponding values of m^2, b^2, and mb are $m^2=4$, $b^2=9/4$, $mb=-3$. Whence

$$(x^2+2x+7/2)^2=(3/2-2x)^2.$$

This equation is equivalent to the two quadratic equations

$$x^2+2x+7/2-(3/2-2x)=0 \quad (1),$$

and

$$x^2+2x+7/2+(3/2-2x)=0 \quad (2)$$

The roots of (1) are $-2\pm\sqrt{2}$, and those of (2) are $\pm\sqrt{-5}$.
These four values satisfy the given quartic.

Solutions were also offered by Merrill Barnebey, Tougaboo, Miss.; Bjoen Conrad, Hightstown, N. J.; A. J. DeGennais, Kipton, Ohio; Brother Norbert,

C.S.C., Chicago, Ill.; Oliver Shannon, Pine Bluff, Ark.; and Dale Woods, Pocatello, Ida.

2638. *Proposed by Ruderman, New York, N. Y.*

If the 4 faces of a tetrahedron have equal areas, then they are congruent, and there are exactly 5 spheres tangent to the planes determined by the faces.

Solution by the Proposer

Let:

A, B, C, D be the vertices of the tetrahedron

a, b, c, d be the faces opposite A, B, C, D respectively, or their areas; the context will be clear as to which is intended.

$\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, \boldsymbol{d}$ be the real vectors for a, b, c, d respectively. They are vectors normal to their respective faces (a, b, c, d) outwardly directed having magnitudes equal to the areas of their faces.

K = the area of each face a, b, c, d for this problem. Note that

$$K = |\boldsymbol{a}| = |\boldsymbol{b}| = |\boldsymbol{c}| = |\boldsymbol{d}|$$

As the sum of the real vectors for any polyhedron, in fact any solid, is zero:

$$\boldsymbol{a}+\boldsymbol{b}+\boldsymbol{c}+\boldsymbol{d}=0,$$

so that

$$(\boldsymbol{a}+\boldsymbol{b})^2=(-\boldsymbol{c}+-\boldsymbol{d})^2$$

or

$$a^2+b^2+2\boldsymbol{a}\cdot\boldsymbol{b}=c^2+d^2+2\boldsymbol{c}\cdot\boldsymbol{d}.$$

The indicated products are scalar or dot products for the vectors. As

$$a^2=b^2=c^2=d^2=K^2,$$

we have

$$\boldsymbol{a}\cdot\boldsymbol{b}=\boldsymbol{c}\cdot\boldsymbol{d}.$$

This permits the conclusion that the dihedral angle formed by a and b equals the dihedral angle formed by c and d, as these angles are less than 180°. Hence, in a similar manner, we may conclude that the other opposite dihedral angles are equal.

As the faces have equal areas by hypothesis, the altitudes from the 4 vertices of the tetrahedron upon the opposite faces are all equal.

Hence, the altitudes in the faces drawn to opposite edges are equal. They are corresponding sides of $\cong rt.\ \triangle s$ which agree in an altitude of the tetrahedron and a dihedral angle, a side-angle-angle situation.

As the faces have equal areas, the sides to which these equal altitudes are drawn must be equal. Thus, the opposite edges are equal.

Hence, the 6 edges of the tetrahedron are equal in pairs, and the faces are congruent as they agree in 3 sides.

This proves the first half of the problem.

To prove the second part we shall use homogeneous tetrahedral coordinates. In this coordinate system, the centers of spheres tangent to the planes determined by the faces may in general be written as $(\pm1, \pm1, \pm1, \pm1)$ where any of the 16 possible combinations of signs may be taken. However, only 8 sets may represent distinct points as in homogeneous coordinates (r, s, t, u) represents the same point as (kr, ks, kt, ku) for $k \neq 0$. In our case we took $k = -1$.

For any point (r, s, t, u) there is a $k \neq 0$ such that kr, ks, kt, ku will represent the directed distances from the 4 planes. Hence, if V is the volume of the tetrahedron, for this k we have

$$kra+ksb+ktc+kud=3V$$

or

$$k=\frac{3V}{ra+sb+tc+ud}$$

Thus, k does not exist whenever $ra+sb+tc+ud=0$. In our problem, k does not exist whenver for some set of signs

$$\pm a\pm b\pm c\pm d=0$$

Hence, whenever the sum of the areas of 2 faces equals the sum of the areas of the other 2 faces, there will be a k missing.

Case 1: If $a+b=c+d$ but no 2 faces are equal, then there will be only one k missing, and we shall have exactly 7 tangent spheres.

Case 2: If $a=c$, and $b=d$, but $a\neq b$; that is, there are exactly 2 sets of equal faces, then there will be exactly $2k$'s missing so that there will be 6 tangent spheres. The cases that will yield a zero k are $a+b-c-d$, and $a+c-b-d$.

Case 3: If $a=b=c=d$, our problem, then at no time can there be the same number of positive and negative signs. In addition to the exclusions in case 2, we must also exclude $a+d-b-c$. Hence, there are exactly $8-3=5$ tangent spheres possible. Their tetrahedral coordinates will be:

$$(1, 1, 1, 1),\ (-1, 1, 1, 1),\ (1, -1, 1, 1),\ (1, 1, -1, 1) \text{ and } (1, 1, 1, -1).$$

All the other combinations of signs yield zero denominators for k and so yield no points.

2639. *No correct solution has been offered.*

2640. *Proposed by John Nayler, Calgary, Alberta, Canada.*

One disc of 20 inches diameter and one disc of 10 inches diameter are cut from a 30-inch diameter disc of plywood. What is the largest disc that can be cut from the remainder of the plywood?

Solution by C. N. Mills, Sioux Falls College, S. Dakota

This problem is a special case of a problem that has appeared in this magazine at various times during the past several years, namely, the Apollonius Circle Contact Problem. Given the radius a, b, and c of three circles tangent to each other, to find the radius of the circle which is tangent to the three circles. The solution is

$$r=\frac{abc}{2\sqrt{[abc(a+b+c)]}\ \pm(ab+ac+bc)}.$$

In the above formula, using the minus sign gives the radius of the circumcircle, and using the plus sign gives the radius of the inclosed circle.

In the proposed problem, let $a=10$, $b=5$, and c the radius of the required circle. Then

$$15=\frac{50c}{2\sqrt{50c(15+c)}-(50+15c)}$$

Rationalizing this equation, and solving for c, gives $c=4\ 2/7$.

A solution was also offered by Merrill Barnebey, Tougaloo, Miss.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2659. *Proposed by V. C. Harris, San Diego, Calif.*

There are two concentric circular sidewalks separated by a street. A person is at a point on the outer sidewalk and wishes to get to another point on the sidewalk. Assuming that he can walk directly across the street or along the sidewalks, only, should he cross or not in order to walk the least distance?

2660. *Proposed by Ben L. Swensen, Austin, Texas.*

Find the area of the square, three corners of which are 3, 4, and 5 rods distant respectively from a point within the square.

2661. *Proposed by Alna Zame, Coral Gables, Fla.*

What is the next term in the series

$$1 \quad 3 \quad 4 \quad 7 \quad 6 \quad 12 \quad 8 \quad 15 \quad 13 \quad 18 \quad 12 \quad 28 \quad 14 \quad 24 \quad 24 \cdots ?$$

2662. *Proposed by Brother Felix John, Philadelphia, Pa.*

If the 6th, 7th, and 8th terms of $(x+y)^n$ are respectively 112, 7 and 1/4, find x, y, and n.

2663. *Proposed by Alna Wayne, Baldwin, N. Y.*

Find the digits represented uniquely by the letters in the addition

$$\begin{array}{cccccc} & & O & N & C & E \\ C & O & D & E & D \\ \hline D & I & G & I & T & S \end{array}$$

2664. *Proposed by J. B. Love, St. Davids, Pa.*

Show that two colors suffice to color any map on a plane when the intersections of the boundaries of all countries are of even order.

RUBBER TO BE VULCANIZED BY ATOMIC RADIATION SOON

Atomic radiation may soon replace heat and chemicals in vulcanizing some rubber compounds.

Irradiation vulcanization will not ordinarily be as cheap as conventional vulcanization. In fact, the actual radiation vulcanization step in rubber processing will probably be more expensive for the next 10 years.

However, irradiation will eliminate many compounding ingredients, and appreciable saving may be introduced by the elimination of such items as curing pits, molds and curing ovens.

Vulcanization, whether with heat and chemical accelerators or with atomic radiation, is the process of curing sticky raw rubber to form tough, bouncy, useful products.

Until someone discovers a method of reducing the radiation dose necessary for vulcanization, and thus reduce its cost, irradiation vulcanization's chief advantages will be:

1. Curing rubber goods that are difficult or impossible to cure by chemical means.
2. Curing thick goods uniformly all the way through.
3. Curing extruded goods, such as tubing, without heat.

Engineers will be free to revise their production lines to capitalize on the high-speed, continuous-flow advantages of radiation cures.

Books and Teaching Aids Received

PHILOSOPHY OF ATOMIC PHYSICS, by Joseph Mudry. Cloth. 136 pages. 14×21 cm. 1958. Philosophical Library, Inc., 15 E. 40th street, New York 16, N. Y. Price $3.75.

MATHEMATICS AND SCIENCE EDUCATION IN U. S. PUBLIC SCHOOLS, Circular 533. Paper. 20×25.5 cm. Pages iv+97. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C. Price $.65.

ELEMENTS OF THE UNIVERSE, by Glenn T. Seaborg and Evans G. Valens. Cloth. 253 pages. 16.5×24 cm. 1958. E. P. Dutton and Co., 300 4th Avenue, New York 10, N. Y. Price $3.95.

RADIOASTRONOMY AND RADAR, by J. G. Crowther. Cloth. 64 pages. 16.5×21 cm. 1958. Methuen and Co., Ltd., Publishers, 36 Essex Street Strand, London WC2, England. Price 10s 6d.

TRIGONOMETRY, by Dorothy Rees and Paul K. Rees. Cloth. xi+318 pages. 15×23 cm. 1959. Printice-Hall, Inc., Englewood Cliffs, N. J. Price $3.96.

HOW TO USE A SLIDE RULE, by Clarence H. Heinke, *Associate Professor of Mathematics, Capital University*, Paper. Pages v+91. 1958. Clarence H. Heinke, 688 S. Remington Rd., Columbus 9, Ohio. Price $2.25.

GEOMETRY CAN BE FUN, Teacher Edition, by Louis Grant Brandes. Paper. Pages iv+249. 21.5×27.5 cm. 1958. J. Weston Walch, Publisher, Box 1975, Portland, Maine. Price $2.50.

NUCLEAR REACTORS FOR POWER GENERATION, by E. Openshaw Taylor. Cloth. Pages vii+144. 14×21.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $7.50.

FREE AND INEXPENSIVE LEARNING MATERIALS, Ninth Edition. Paper. 256 pages 14×21.5 cm. 1959, Division of Surveys and Field Services, George Peabody College for Teachers, Nashville, Tenn. Price. $1.50.

EDUCATORS GUIDE TO FREE TAPES, SCRIPTS AND TRANSCRIPTIONS, Fifth Edition. Compiled and Edited by Walter A. Wittich and Gertie Hanson Halsted. Paper. Pages xiii+229. 21×27.5 cm. 1959, Educators Progress Service, Randolph, Wisconsin. Price $5.75.

THE AIR, by Edgar B. Schieldrop. Cloth. 256 pages. 15×23 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street New York 16, N. Y. Price $12.00.

LIQUIDS AND GASES, by Alexander Efron. Paper. Pages vii+117. 14×21.5 cm. 1958. John F. Rider, Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $2.10.

METALLIC RECTIFIERS AND CRYSTAL DIODES, by Theodore Conti. Paper. 164 pages. 14×21.5 cm. 1958. John Rider, Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $2.95.

TEACHERS' EDITION, ACTIVITIES IN BIOLOGY—THE LIVING WORLD and TESTS TO ACCOMPANY BIOLOGY—THE LIVING WORLD, by Francis D. Curtis, Paper. Pages vii+88. 17×23 cm. 1958. Ginn and Company, Statler Building, Boston 17, Mass.

LOGIC, MACHINES AND DIAGRAMS, by Martin Gardner. Cloth. Pages ix+157. 15×23 cm. 1958. McGraw-Hill Book Co., Inc. 330 W. 42nd Street, New York 36, N. Y. Price $4.75.

THE INTEGRATION OF HUMAN KNOWLEDGE, by Oliver L. Reiser, *Professor of Philosophy, University of Pittsburgh*. Cloth. 478 pages. 14×21 cm. 1958. Porter Sargent Publisher, 11 Beacon St., Boston 8, Mass. Price $8.00.

Book Reviews

PHYSICS FOR OUR TIMES, 1958 Edition, by Walter G. Marburger and Charles W. Hoffman. Cloth. 602 pages. 16×23.5 cm. 1958. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y.

To the members of Central Association, the senior author of this text needs no introduction. He is noted for his activities as a teacher and science educator. This revised edition of *Physics for Our Times* has many worthwhile features as a high school physics text. It discusses the traditional topics in physics—mechanics, heat, sound, electricity, and atomic physics.

Some of the features which impressed the reviewer are as follows. "You will be interested to know" is a feature mentioning briefly bits of historical information. These are complete in themselves or can serve as motivators for finding more materials on the topics. There are discussion questions throughout the chapters. The chapter end material consists of a very comprehensive summary titled "Highlights." Problems are in two groups (A and B) to allow flexibility in problem assignments. "Things to Do" are suggestions for student projects and demonstrations. Scattered throughout the book at the end of chapters or units is a section titled "Sidelight." These contain the very latest data on current science experiments, as satellites, and I.G.Y. discoveries. The many diagrams are meaningful and the use of full color pictures in the light-color section adds much to the text.

While not as rigorous mathematically as some physics texts, this book would be an excellent text for most high schools, and should be examined by any teacher selecting a new text.

E. WAYNE GROSS
University School
Bloomington, Indiana

AMERICA'S NATURAL RESOURCES, edited for the Natural Resources Council by Charles H. Callison, *National Wildlife Federation, Washington, D. C.* Cloth. Pages x+211. 13.5×20.3 cm. 1957. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $3.75.

This book, sponsored by the Natural Resources Council of America, includes a useful summary of current information on the conservation of primarily the renewable natural resources. Each of the thirteen chapters is written by a well recognized leader in one of the specialized conservation fields.

The first two chapters briefly discuss the relation of ecology to conservation and the importance of managing the nation's resources in the face of our growing population. Soil, water, grasslands, forests, fish and wildlife are the renewable resources covered. Attention is given in one chapter to the necessity of setting aside parks and wilderness.

The significance of land, in a spatial sense, and the principles that should determine the most effective use of land indicate a need for a national land policy according to one of the authors.

The book provides useful information on the conservation of natural resources for the lay reader and may be recommended as a good reference for the teacher and student who wish to gain a better understanding of the important principles in the management of our renewable resources.

HOWARD H. MICHAUD
Department of Forestry and Conservation
Purdue University
Lafayette, Indiana

SOIL CONSERVATION, by J. H. Stallings. *Research Specialist, United States Department of Agriculture, Washington, D. C.* Cloth. Pages x+575. 15×23 cm. 1957. Prentice Hall, Inc., Englewood Cliffs, N. J. Price $9.00.

The extensive material presented in this book is such that it could well be considered a handbook of soil conservation. The author's twenty years' experience in different capacities in the Soil Conservation Service of the United States Department of Agriculture has expressed itself in a well-documented presentation of the efforts and accomplishments of the soil and water conservation movement of the last two decades.

Soil Conservation contains four divisions: Part 1 deals with the historical phases of soil erosion both in the old world and in the United States, Part 2 with the fundamental considerations of soil conservation, Part 3 discusses the important soil conservation practices, and Part 4 covers the individual farm conservation plan and watershed planning.

During the past eight years the author has served as Research Specialist in the research Division of the Soil Conservation Service. In the preface of the book he states "that in this capacity, one of my major duties was to assemble, analyze, and interpret all available data bearing on soil and water conservation." As a result, the author has done an excellent job of showing the relation of each of the four divisions to the others by integrating and interpreting the scientific data. One is impressed by the tremendous accumulation of research that has contributed to the science of soil conservation during recent years.

Each chapter represents an authoritative treatment of the subject, documented by numerous research investigations and a long list of references at the end of the chapter. The problems of soil conservation associated with erosion are adequately covered. While the author mentions the relation of maintaining fertility to soil losses, it seems to this reviewer that a separate chapter would strengthen this point.

The book contains many excellent photographs, tables, charts, and graphs that increase the value of the information presented.

There is sufficient material in the book for a college level course in soil conservation. Teachers of high school science may find much valuable material suggesting research possibilities in the physical and biological aspects of soil conservation. Land owners, conservationists, foresters and other resource specialists with responsibilities in the field of soil conservation will find the information especially useful.

HOWARD H. MICHAUD

BASIC OF DIGITAL COMPUTERS, by Johns S. Murphy. 3 volume set. Paper. Vol. 1–116 pages; Vol. 2–133 pages; Vol. 3–136 pages. All 15×23 cm. 1958. John F. Rider Publisher, Inc., 116 W. 14th St,. New York 11, N. Y. Price $2.50 per volume; $6.95 per set.

This is the latest of the Rider "picture-book" courses in which the author has attempted to present the fundamentals of digital computer theory without presenting details of a specific computer system. It is assumed that mastery of the material in these volumes will prepare the technician for work on any computer system.

An effort has been made to present as much of the subject matter as possible in picture form for purposes of clarity. However, it is the opinion of this reviewer that some of the illustrations are of little value since they do not simplify anything, but seem to be presented just to have a picture. Perhaps this is an unfair criticism since most of the illustrations adequately convey the concepts for which they are intended.

Volume One covers the development of computers, theory of computer arithmetic, data representation, programming, circuiting, and control. Volume Two treats circuits, types of signals, magnetic cores, and decoders, counters and units. Volume Three handles such aspects of computers as memory control systems, and input-output equipment together with a discussion of timing.

It is the opinion of this reviewer that the author has done an excellent job of presenting a difficult topic in a manner that is interesting and should make the material easy to understand for anyone with a background of elementary

electronics. It is recommended for anyone interested in basic digital computer theory.

J. Bryce Lockwood
Highland Park Junior College
Highland Park, Mich.

Biology, by Elsbeth Kroeber, Walter H. Wolff, *William Cullen Bryant High School, Queens, New York*, Richard L. Weaver, *University of Michigan, Ann Arbor, Michigan.* Cloth. Pages vi+608. 15.5×23 cm. 1957. D. C. Heath and Company, Boston 16, Massachusetts. Price $4.68.

Biology textbooks have been undergoing a number of changes during the past few years to make them of more interest to the high school student. This text does much to make biology an enjoyable fascinating study. A variety of illustrations and pictures, with the use of color, are used to provide important biological information. The use of color is good, but at times the contrast and the colors used may tend to give a rather unrealistic picture.

New terms and many of those with which the student may not be familiar are in bold print in the context of the paragraph. There has been a wealth of material included in this textbook but certain passages may be difficult for the average or slow student in biology.

Each chapter ends with a summary of what has been learned, a list of useful biology words, test yourself questions, problems to think about, do it yourself suggestions and short list of references. This material at the end of each chapter should be of value to the teacher as well as being an aid to the student of biology.

The appendix has been used to briefly illustrate and describe different representative phyla of the animal kingdom other than man. Teachers interested in the study of structure may find here the kinds of information they have been looking for in a textbook.

Emphasis throughout the book is on human biology. The first chapters deal with the cell as a basis for all life. The following units cover the many functions of the human body. Conservation, as the last unit, is discussed in relation to man and living things. This unit seems to be well done and should appeal to the reader.

This is one textbook, covering all phases of general biology, that should be reviewed by any group interested in the selection of a new book covering all phases of general biology with an interesting presentation that will appeal to their students.

Nelson L. Lowry
Arlington High School
Arlington Heights, Illinois

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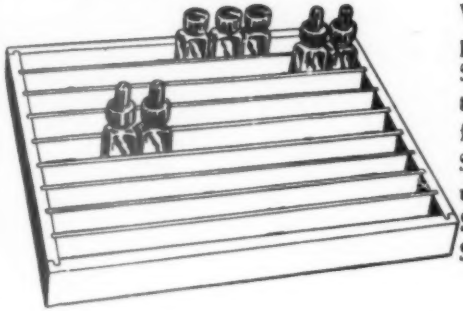

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